SCIENCE

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MSS. intended for publication and books, etc., intended for review should be sent to Professor J. McKeen Cattell, Garrison-on-Hudson, N. Y.

SCIENTIFIC TRUTH AND THE SCIENTIFIC SPIRIT[1]

IN appearing before you this evening in my present rôle I can not but recall an incident of fifty-five years ago, which often recurs to my mind when I think of the events of to-day.

The trustees of the Smithsonian Institution in 1861 were preparing their programme for the year, and in this programme were courses of lectures to be given to the public on a series of selected topics. Their intention was announced and they were importuned to devote those lectures to what was at that time in everybody's mind. It was the first year of your great war of the Secession. I say your war, but I might, with some justification, have called it our war, for there fought in the ranks of the armies of the North 68,000 British citizens, of whom 45,000 were Canadians, and of the latter 15,000 lost their lives. There were even then stop-the-war people, prototypes of the Fords, the Akeds, the Jane Addamses and the Lloyd Joneses of to-day, futile, mole-visioned and cloister-minded, who imagined that the great conflict could be prevented by talking and they wished to avail themselves of the opportunity the lectures might present of showing how it could be done.

The trustees apparently wished to be neutral, perhaps they were uncertain what the upshot of the conflict was going to be, and this may have helped them to decide, as they did, that all war topics should be

[1] Address delivered at the annual dinner of the Columbia Biochemical Association, February 10, 1916.

excluded from their program. To secure that they invited Professor, afterwards Sir Daniel Wilson, of the University of Toronto, to give a course of lectures on "Prehistoric Man." Professor Wilson was eminent for his attainments and achievements in many fields, but he was chiefly known at the time as a pathmaker in what were then the trackless wilds of the earliest history of our race, and, therefore, the selection of him as a lecturer on the subject could not have been more aptly made. It was a fortunate selection from another point of view. His subject could not be remotely associated with the war then begun, but, had it been otherwise, his habit of mind prevented him from alluding to it in his lectures, and not even once in his conversation during his stay in Washington did he indicate the slightest interest in the great struggle. There were occasions when he could have referred to it. Frequently during the delivery of his lectures the boom of cannon heard in the lecture room—coming from across the Potomac—punctuated his sentences. According to the late Dr. Otis T. Mason, who was my informant on this subject, he left as a memory of his visit a reputation for mental detachment that was Olympic in its character.

This evening I appear before you in a rôle which is in some respects parallel to that filled by Sir Daniel Wilson on that occasion, but there are in it contrasts also. Your country, your nation is now at peace and it is my country that is at war, engaged in a struggle unparalleled in history. Canada has already played a part and she is preparing to play a larger one. She is to increase her army of 200,000 men to half a million, that is, to train and arm five men out of every twelve of the male population between the ages of eighteen and forty-five. That will indicate the magnitude of the task we have undertaken. There can be no mistaking the seriousness with which we regard what is before us. Our young men are preparing to do their duty and to pay the toll that may be exacted. Daily through my laboratory windows comes the sound of the drilling of more than seventeen hundred men, which goes on from morn to night on our university lawn. We have already sent seven hundred of our students and young graduates overseas on active service and we have now a continually lengthening roll of honor with its sad, yet noble, memories of those whom age shall not weary nor the years condemn. The end may be far off and the future is dark and heavy with fate, but we are going forward with the determination that, though life will never again be as it was in the joyous, carefree past, a new world shall come into being as a compensation for the sacrifices that we are making and are yet to make. We are certain above all things of one result, and it is that this war is forging on the anvil of destiny, in the fierce furnace heat of the conflict, the scattered, loosely-knit portions of our Anglo-Celtic empire into an organization, an instrument that shall be a guarantee of happiness and liberty to countless millions yet unborn.

It is the thought of all these things crowding in on my mind that prevents me from adopting the absolutely detached, Olympic mind that Sir Daniel Wilson displayed when your nation was being welded into one in the furnace heat of the great Civil War. I am not, however, going to allow these thoughts to crowd out those which it is my duty to express to you on this occasion. I must look forward, as you must also, to a time when the welter of baleful hatred and paleolithic fury of the

hour will be past, though not forgotten, to a time when men of science of all nationalities may, under better auspices, and in spite of the chauvinism that will be the result of this war, cultivate once more a camaraderie on the intellectual high road of life. And in looking forward we must strive to strengthen those forces which, out of all the wreckage of to-day, remain to assist us in restoring what we, two years ago, were wont to believe could never be swept away.

What are those forces? They are scientific truth and the scientific spirit, both of them intangible entities or principles, but for all that destined to play a part in the restoration of the world to sanity.

It is upon these that I am to dwell this evening, and I have chosen them as the subject of my address in the hope that, in holding your attention for the moment, I may direct your thoughts to questions which are of enduring interest to all workers in science.

To workers in biochemistry these topics are of fundamental importance because our attitude toward them, our comprehension of their significance, determine our usefulness as scientific investigators. As students of the phenomena of living matter we are constantly in touch with problems which, to many, seem inscrutable, inexplicable on the basis of our present knowledge. There is in the make-up of our personalities a tendency to classify the inexplicable as transcendental and to believe that in living matter there operate forces that can never be scrutinized and examined as we examine the forces of the ordinary physical world. That tendency of mind, from which I say few are wholly free, is, when unchecked, a negation of the scientific spirit, and to a mind more or less influenced by it there can be no scientific truth, for the latter is the product of the scientific spirit.

There may be some who will ask "What is truth?" They ask the question not in the spirit and intent of the procurator of Judea, but because they are perplexed by the irreconcilable interpretations of the term "truth" as advanced in the discussions amongst the different schools of philosophical thought. The perplexity is to a certain extent natural, but it ought not to prevent us from finding an answer to the question which will meet the tests, not only of daily life, but also of the world of science, as a brief consideration of the doctrines of two diametrically opposed schools of thought may show.

Amongst the adherents of one of these schools, which I may, for the sake of brevity, call the absolute school, truth is a concept reached by processes of more or less rigid speculation and reasoning, in which, however, introspection plays a large part, explaining the world, reality and mind in terms which are wholly of dialectical coinage. The central doctrine of this system of thought is that reality and appearance are but manifestations of the activity of an entity freed or absolved from all limitations of time and capable of all that we can conceive and more, an entity that is, in consequence, denominated the Absolute. The Absolute is, in the language, some would say, in the jargon, of the school, but truth itself because it is claimed to be the product of the final analysis of the phenomena of mind and reality.

This concept of truth commends itself to minds of a rare type, chiefly those of the cloister or the study, but never to those representative of the world of action. I do not wish to be understood as deriding it or the processes by which it is reached, for I recognize that the human mind must ex-

plore its own depths and exploit its own processes, whatever the result may be, yet I would point that the world is not peopled wholly by Greens, Cairds, Bosanquets, Bradleys and Royces, and that the life and thought of the exoteric many can never but remotely be influenced by this doctrine of truth.

The other school of philosophy is a proponent of a doctrine of truth quite different from the product of pure intellectualism and which can be understood and applied by the many to daily life, and because it can be of service to them it can be absolved from the charge that "it bakes no bread." This school of philosophy holds, as its cardinal tenet, that truth is a body of beliefs or generalizations that work when you apply in it in your needs. The truth in a particular case is the generalization, great or small, that you find in accordance with the facts, and the facts themselves are isolated truths, the products of your experience, that you accept as satisfying your intellectual tests. Whatever works then in daily life is truth, and, if a generalization, or belief, can not be so applied, it has no function or significance intellectually or practically, and can not be truth as it is conceived by the disciples of this school.

This school of philosophy is known as the pragmatic school and it is generally supposed to have been founded within our own time by the late C. S. Pierce and Professor William James, of Harvard, and Dr. F. C. S. Schiller, of Oxford, and Professor John Dewey, of Columbia, who still remain its leaders. The school, however, represents an attitude of mind that has influenced the race since its origin one or more millions of years ago. Ever since the middle of the Pliocene Age, or, perhaps, even since the end of the Miocene, man has had to struggle with his environment, and that very struggle postulated a system of beliefs and generalizations, which, if they served him, represented to him truth. The beliefs and generalizations did not work, if he failed in the struggle and was exterminated. They were, of necessity, at first of the crudest, the most barbaric type and limited in their scope and application to the needs of the moment, but they were changed as they slowly underwent the test of experience, and the beliefs and generalizations of one age were discarded wholly or became the superstitions of succeeding ages. Even to-day the vast majority of mankind regard their beliefs and generalizations as true because they work or give a satisfactory explanation of the scheme of things as it appears now.

That the pragmatic point determined what truth was in the mind of prehistoric man may be gathered from the study of the beliefs and practises of those tribes which are still in the prehistoric stage of culture. Sir John G. Frazer, the author of "The Golden Bough," and one of the profoundest students of the history of human culture, in his work "Psyche's Task" claims that the evolution of some of our most cherished convictions and principles, such as the sacredness of human life, sexual morality, the rights of property and our conception of social order, was promoted by the beliefs and generalizations of prehistoric races. These beliefs and generalizations now appear to us as superstition, and of the grossest character in some respects, but this very superstition in promoting those convictions and principles on which the whole fabric of society rests has rendered a great service to humanity. Sir John Frazer admits that superstition has been productive of evil in the history of the race, but this should not blind us to the

benefit it has conferred, and he gives special point to all this by a dictum which for its brevity and concentrated wisdom is well worth remembering:

Once the harbor lights are passed and the ship is in port, it matters little whether the pilot steered by a Jack o' lantern or the stars.

The history of the human mind is then that of long ages of discipline in pragmatism. It is the pragmatic mind that has brought man along the road of progress through the million or more years of the prehistoric period to the stage of civilization of to-day. It is the pragmatic mind that will lead him, indeed force him, along the road of progress in the many, many millions of years during which the race will possess the earth. In all that time to come he will refine more and more the processes by which he arrives at what he will regard as truth and he will subject it to ever rigider tests as the millenia pass. As a result, there will be many a discarded belief and generalization once looked upon as truth, just as there has been in the past a long series of beliefs and generalizations which for a time worked and then became superstitions. Truth then will have its paleontology just as life has, with its myriads of forms which have passed away.

To those who are inclined to accept the intellectualist's teachings, this view of truth as earth-born rather than heaven-born, appears repellant and degrading. It does not seem possible for them to idealize it as they can idealize what Carlyle calls "The eternal verities." They, with Chaucer, may hold that "truth is the highest thing a man may keep," and they are prone, accordingly, to sublimate it, as the intellectualist does, until it has no earthly affinities. They should remember that truth of the absolute school has had a repellant history. Men have in the past assumed that they were in the possession of absolute truth and they attempted to compel all others to accept it also. Not to receive the absolute truth, they held, was to murder the soul, and to prevent such murder the extremest cruelty was considered justifiable. Hence arose persecution, religious wars, death at the stake and on the scaffold, massacres of thousands and relapses into barbarism. Absolute truth has then its paleontology to remind it that it, like the truth of pragmatism, is subject to growth, to evolution, and that it may ripen only with the ages.

From all that I have said it follows that the long discussions on the nature of truth as the pure intellectualist understands it have been but vain dallyings with illusory ideas. There is no absolute truth knowable to the human mind. All that passes for such can, at best, be but a remote approximation to what may, in the final cast of thought in the far-distant future, be a dim limning of the ultimate, the absolute, the fundamental significance of the relations of reality and mind.

Now what is the bearing of all this on scientific truth?

Its significance lies in the fact that the representatives of science must always face the question of the validity of its position as an exponent of organized knowledge. There is in the popular mind a notion that the processes by which the facts and generalizations of science are established are different from those which are employed outside of the laboratory or observatory to establish the working hypotheses of daily life, or which were employed, more or less unconsciously, in the development of the most firmly founded principles on which our present social order rests. This has caused science to be regarded as a thing apart, as the lore of an oracle whose pro-

nouncements it is profanity to reject. One hears in popular speech such expressions as "science says . . ." or, "according to science," or "science teaches" and this indicates that in the mind of the average man there is a more or less developed cult of science as an infallible entity, personality, or divinity, which, like Minerva, has no earthly or human origin. It is perhaps not the popular mind that is wholly to blame for this. When one reviews the discussions and polemics of the last fifty years, which have arisen from the conflict between conservative and advanced thought, and, especially, advanced thought based on direct observation and experiment, there has not been wanting a species of dogmatism in not a few of the representatives of science, that suggests the claim of a degree of infallibility which the popular mind, superficial as it is, and because of the achievements of science, has been and is inclined to accept. It is true, the clearest-minded amongst the representatives of science never by speech or silence encouraged such a claim. Tyndall, Huxley, Kelvin, Helmholtz, Virchow and Pasteur have, in set terms, again and again insisted that science is not infallible. Huxley, throughout his long crusade for the recognition of science as a force making for progress, was specially insistent on the possibility of error in science. He it was who defined science as nothing but trained and organized common sense, a definition that ought to acquit it of the charge of claiming infallibility.

In spite of these disclaimers, the taint of a reputation for infallibility remains, and it not infrequently draws from the superficial, as well as from some who ought to know better, the criticism that the judgments of science are unstable and ought not to be regarded as having any validity when they are opposed to the established beliefs and the dogma of the day. Sometimes the exponents of the older learning denounce science as falsely so-called, or term it pseudo-science. At one time that was the stock charge against science, and it had its effect on the unthinking. It still is launched against science chiefly in the polemical publications of the orthodox theological school.

It is, however, when the criticism comes from the rank and file of the army of science that it does the most mischief, and especially so when it is urged in defence, not of religious beliefs or dogmas of a philosophical school, but of dogmas like vitalism, the acceptance of which postulates a negation of the established methods of science.

It is not difficult, though not fair, to charge science with pretensions to infallibility, then to recall its mistakes, its discarded theories and generalizations and thereby to impugn its claims to speak with authority on matters with which it busies itself. That appeals occasionally to the man in the street and it gains a little, perhaps desired, notoriety for the critic, but does it help us in the final cast of things to question the hard-won achievements of the human mind and say that they are naught? By what other methods than those followed in scientific research can organized knowledge be gained? Is it by intuition, revelation or the dialectics and pipe-dreams of the intellectualists? It is, therefore, beside the mark for Von Uexküll to ask "Was ist eine wissenschaftliche Wahrheit?" and to answer "Ein Irrtum von heute." In a different spirit and with a world of difference in ultimate meaning is the observation of Huxley that "history warns us that it is the customary fate of new truths to begin as heresies and to end as superstitions."

Science, then, is not infallible and never can be. Equally lacking is the quality of infallibility in scientific truth. The essence of a truth in science lies in its power to explain phenomena in a satisfactory way. If it does not do this, then it is not a truth. In a certain stage of the development of scientific knowledge a theory is found to explain or relate all the known facts in a particular range of phenomena. This is the source of the satisfaction it gives to the scientific mind and at that stage it is accepted as a truth. But subsequently discovered facts in the same province may refuse to be so explained or related, and the previously accepted truth will, consequently, be discarded for one that will give this service.

An illustration is to be found in the history of the theories of light. Newton held that light emanated from its source in the form of excessively minute particles or corpuscles, which were supposed to travel with enormous velocity. This "corpuscular" theory in his day and for a hundred years after seemed to explain all the then known phenomena of light. It was not only satisfactory in this respect, but it stimulated further inquiry in the subject. This eventually led to the promulgation of the "undulatory" theory, according to which light is but a wave motion in the cosmic ether. For the last hundred years this has been accepted as a truth, but in its turn it is failing to explain all new facts as they are ascertained, and its acceptance in its original form as a truth may eventually terminate.

If this is scientific truth, what is there to prevent it from running riot, confusing and misleading rather than guiding?

The only preventive force is the scientific spirit. It is a development of the quality or tendency of the mind which has compelled man in all the periods of his history to discard or to recast his truths because they do not work, and to accept new ones because they do work. That tendency in common life has operated crudely and slowly, it has caused countless mistakes and the temporary acceptance of countless errors, but it has brought us to our present stage of civilization. It is indeed nothing else than the pragmatic spirit. The scientific spirit is the pragmatic spirit trained in the strictest fashion to accept only what answers rigid tests and reinforced by an intense curiosity or desire to know. The very essence of this spirit is manifested in the habit of unceasing, relentless criticism. Without such incessant criticism there would be chaos in science. The scientific spirit, as thus understood, is an all-powerful factor in establishing scientific truth.

To some of you, perhaps to many of you, what I have said may appear as a restatement of a series of truisms, and I am prepared to admit that. I have, however, dwelt on these matters at length because they are of fundamental importance to men of science generally, and, amongst these, to biochemists, especially of the younger generation, who have now to meet an extraordinary situation in which these matters are involved.

A brief sketch of the history of biochemistry to the present date will demonstrate what this situation is.

It would be difficult to say when the history of biochemistry actually began, for all through the last century a number of contributions to chemistry were made which can now be regarded as contributions to biochemistry. The history of biochemistry, however, as a distinct department of knowledge, may be said to have begun with Hoppe-Seyler in 1867 in the work from his laboratory, which he subsequently published under the general title of "Medicinische-Chemische Untersuchungen." The

number of publications from all sources, which appeared annually during the seventies was small, and even in 1884 when I began to interest myself in the subject it did not, all told, exceed more than three hundred a year. It was possible for a biochemist then and for a few years thereafter to keep in touch with all advances in his subject, but eventually the number grew and in 1905 the year's output of biochemical publications of all kinds was estimated to be about three thousand five hundred papers. It did not cease to grow and the output of 1913 was more than six thousand.

The task of the scientific spirit in 1870, so far as the exercise of relentless criticism was concerned, was easy, for the dozen or more biochemists could supervise the whole field of production and pronounce judgment. That function was carefully and deliberately performed. It is on record that when Miescher, who had been for some time a student in Hoppe-Seyler's laboratory in Tübingen, offered his paper, now classical, on nuclein, for publication in the "Medicinische-Chemische Untersuchungen," Hoppe-Seyler would not publish it till he himself had worked over the whole subject and verified all the observations of Miescher. The publication of the paper was, in consequence, delayed two years.

What could be done in 1870 can not be done now, when the mass of literature being poured out in every department of biochemistry is so overwhelming. It is still possible for the head of a laboratory to censor its productions and a number of the leaders exercise that function, but what they do in this subject ameliorates the situation only to a slight extent. There is still, as any one can see, too little criticism of value in the annual output. One gets the impression, in reviewing the literature on a subject, that the contributors to it regard criticism as not within their province, and that they are anxious to get their own views on record without going through the labor of preparing a critical review of that literature. There is in consequence an ever increasing dependence on Jahresberichte, Centralblätter and Ergebnisse. Even when the function of criticism is exercised the situation is not always thereby bettered, for the criticism not infrequently is slipshod or specious, and the result is only polemics, or it is completely ignored.

It may be urged that the criticism to be effective would increase the length of each contribution, which on the average is sufficiently long already. The answer to this is that effective criticism would in the end not only shorten the length of the papers, but also lessen their numbers.

The haste to publish and the tendency to multiply unnecessarily the number of papers are vices which should be curbed. The fact that they are so prevalent is due to the absence of effective criticism.

In claiming that criticism is the essence of the scientific spirit, I must not be understood as justifying criticism of the undiscriminating or reckless type. That is utterly senseless and is a graver fault than the absence of all criticism. Criticism, to be effective, must be judicial, honest and, above all, courteous to the object of it. Criticism of that type no man can refuse or reject and it is extremely valuable to the individual who is subjected to it, as he will admit sooner or later if he is of the right sort. It is the only means of determining whether what he offers as a contribution is going to work.

To inculcate right standards of criticism there should be given in every university a course of lectures on ethics for all those who propose to devote themselves to a scientific career. There might even be, I would suggest, a brotherhood like the ancient Brotherhood of Hippocrates, the members

of which would vow to devote themselves to the cause of truth, to deal justly and courteously with one another and with all laborers for that cause and to keep the scientific record purged of what is false or mean.

Not to dwell further on this subject, I will now briefly emphasize the central points of this address:

The first is that absolute truth is not knowable, and that even to the end of time it will be so.

The unfinished window in Aladdin's Tower
Unfinished must remain.

The second point is that scientific truth of any age is that which works and consequently it may change and present a new aspect with each succeeding generation.

The third is that the scientific spirit is, when rigorously exercised, the only test of what works or what is scientific truth.

The last point is that science is not and never can be infallible, and we should be thankful for that, for, if it assumed infallibility, the progress of the human mind on the path of truth would cease.

Before I conclude finally I would call attention to a rendition of the ideal scientific spirit which is to be found in a passage of Tennyson's "Ulysses." The old hero is there represented as having, after ten long years before the walls of Troy and ten more years of peril and adventure on the sea, returned to Ithaca, his old home, and as now resolving to take up the life of change and discovery even though the gulfs should wash him down. The passage which I quote should be indelibly fixed in the memory of every scientific worker:

I am a part of all that I have met;
Yet all experience is an arch wherethro'
Gleams that untravell'd world whose margin fades
Forever and forever when I move.
How dull it were to pause, to make an end,
To rust unburnish'd, not to shine in use!
As tho' to breathe were life! Life piled on life
Were all too little, and of one to me
Little remains, but every hour is saved
From that eternal silence, something more,
A bringer of new things, and vile it were
For some three suns to store and hoard myself,
And this gray spirit yearning in desire
To follow knowledge, like a sinking star,
Beyond the utmost bound of human thought.

A. B. Macallum
University of Toronto

EUGENE WOLDEMAR HILGARD, A BIOGRAPHICAL SKETCH

Eugene Woldemar Hilgard was born January 5, 1833, at Zweibruecken, in Rhenish Bavaria, the son of Theodore Erasmus and Margarethe Hilgard, and was the youngest of a family of four sons and five daughters. His father was a lawyer, holding the position of chief justice of the court of appeals of the province. Judge Hilgard, having been born and educated under the shadow of the French Revolution, and being of pronounced liberal views, stoutly opposed the supersedence of the code Napoleon by the illiberal laws of the old régime. In 1836, when at the fullness of a successful career, he determined to emigrate to America with his family and settled on a farm at Belleville, Illinois. As the public schools of that day were quite primitive, Judge Hilgard personally undertook the preparation of his sons for entrance to the universities. Eugene was in readiness in 1849 and in that year returned to Germany to attend the University of Heidelberg, graduating with honors and a doctor's degree with *summa cum laude* in 1853. This degree was re-issued to him in 1903 as a "golden degree" in recognition of half a century's good work for science. He studied also in Zurich and Freiberg, in Saxony. After graduating in 1853 he visited Spain and met Miss J. Alexandrina Bello, daughter of Colonel Bello, of the Spanish army, whom he married several years later. Returning to America, he began geological exploration work in Mississippi in 1855 and was appointed state mineralogist of that state in 1858. In 1860 he revisited Spain, married

Miss Bello and resumed his work in Mississippi in November of that year. During the intervention of the Civil War he pursued the chemical work required by the Southern Confederacy. In 1866 he was chosen professor of chemistry in the University of Mississippi, and later professor of geology, zoology and botany. In 1872 he left Mississippi to take a position on the faculty of the University of Michigan, but remained there only two years, when he was called by the regents of the University of California to California in 1874. While developing agricultural instruction in the university, he proceeded with research work immediately after his arrival in California and published his first results in 1877. His work in the investigation of soils in connection with their native vegetation, of the influence of climate on the formation of soils and especially of the nature of "alkali soils" and their reclamation, a problem quite new not only in this country but in other arid regions, achieved for him a reputation as wide as the world of science. It brought him recognition on numerous occasions. Mississippi, Columbia and Michigan universities, as well as the University of California, have bestowed the Doctor of Laws degree upon him. The Academy of Sciences of Munich presented him with the Liebig medal for distinguished achievements in the agricultural sciences and the international exposition at Paris, in 1900, gave him a gold medal as a collaborator in the same research.

Soon after coming to California he directed the agricultural division of the northern transcontinental survey. From 1879 to 1883, in connection with his university work, he assumed charge of the cotton investigation of the census of 1880 which he projected and carried out on a broader plan than ever before undertaken. During the whole period of his academic career Professor Hilgard was constantly active in authorship. In addition to formal reports and memoirs, he wrote much for agricultural and scientific periodicals. His greatest book is "Soils of Arid and Humid Regions." The simple form of this work is "Agriculture for Schools of the Pacific Slope," undertaken in collaboration with Professor W. J. V. Osterhout, formerly of the University of California.

In 1892 he revisited Europe and was received with distinguished honor by his colleagues in science in the German universities and experiment stations, and by invitations to deliver public addresses on the subjects in which he had made the chief achievements.

Since 1910 Professor Hilgard's advanced age rendered him unequal to the pursuit of extensive tasks. He maintained, however, his membership in several scientific societies and was vitally interested to the last in investigations connected with his science.

The greater part of Hilgard's career was spent at the University of California. Of the many and various problems which he faced at the beginning of his work there, three seem at this moment to give best clue to the masterfulness of the man and fullest understanding of the breadth and depth of his success:

First: the conciliation and conquest of his farming constituency, by demonstration of practical and indispensable value in the work he could do.

Second: the enforcement of recognition of agricultural studies as entitled to the dignity of higher learning and as possessed of pedagogic value.

Third: the securing of funds to pursue research which could alone yield truth about natural conditions affecting California farming, and to increase his working force, without which he could neither get the truth nor teach it in its several branches and applications.

I clearly recall an early instance of Hilgard's method. I was present at a farmers' meeting in San Francisco in 1876, apparently called to see just how far the college of agriculture at the University of California had fallen. The room was not large and was crowded with men of some prominence in farming and hostile to the university because they really believed that the college of agriculture ought to be snatched from ruinous association with a so-called "classical institution." It was a stormy assembly, but when

there came a lull the chairman asked Hilgard to speak. He rose alertly, showing them a slim, graceful figure, and when he had folded and pocketed the blue glasses which a long-continued eye trouble forced him to wear, they saw a scholarly face illumined with an eagerness, cordiality and brightness of expression which seemed to say to them: I never was in such a delightful place before in my life. Before he could say a word he had them transfixed with surprise and curiosity, and when he began to speak in a low, conversational voice, with an accent which compelled them to listen closely, every man was at attention. He was saying that he was glad to meet them; that no one could do much for farming unless he had personal knowledge and support of farmers; that he had listened with interest to what they had been saying and much of it doubtless would be helpful to him; that other things they could talk over and agree upon when they became better acquainted; that he had come to California to try, with their help and support, to know California, from the rocks to the sky, and proposed to use all that he had learned in other lands merely as a help to begin to know California, which he already perceived was different from any other land in which he had lived and worked. He wished to work from California outward, not to try to fit old theories to a new state. He had always been interested in differences and wanted to see what they were and how they worked in farming. On his father's farm in Illinois he learned that the soil was not all alike and he had been told that soil differed when it came from different rocks, when it was moved about in different ways, and when other things were mixed with it, and that since boyhood he had been studying the rocks, the soils, the plants, to see what was in the soil and in the plant in the hope of matching them up to get the best crops and the most money in farming. Then followed a charming half-hour with soil formation and movement, tillage, fertilization, etc., without a scientific term, without reference to a chemical formula, all straight farming talk about soils and plants. Finally he said he had come to find out how these things worked in California.

Within a few years Hilgard was able to render his first great service to the community in which he lived by promoting a sympathetic understanding between the farmers of the state and scientific learning, so that the college of agriculture became firmly established as a part of the state university by constitutional amendment. The influence of this achievement was wide-reaching, for it has proven a rock upon which efforts for dismemberment of land-grant universities in other states have been dashed to pieces.

Hilgard's scholarly preparation was wide. Aside from scientific branches, he knew his Latin and his Greek and the literatures of them, and only the distinguished professor of German of that day could surpass him in conversational scope in modern languages. And he loved all this learning and constantly used it familiarly, while, beyond all conscious employment of it, there it was forming his thought, gracing his style and in every way influencing his action and enriching his life.

He was thus able ultimately to command the interest and respect of both the scientific and classical portions of the university community in his service to the state. He was always broader than his own science. He was a real man and a true philosopher.

Hilgard's work was permanently successful because with clear vision he founded it upon principles the soundness of which has since been demonstrated and generally recognized. In his first report, published in 1877 he said:

> A knowledge of facts and principles and not the achievement of manual dexterity, must be the leading object of a truly useful course of instruction in agriculture. . . . Object teaching should be made the preeminent method of instruction in natural, and more especially in technical science. Manual exercise should be made the adjunct of the instruction in principles.

Thus Hilgard announced at the very beginning his adoption of the laboratory and field method of instruction and he pursued it so far as he could command the outfit for it.

That the structure of Hilgard's achievements in the University of California was his own from the ground up, appears from another extract from his first report.

The appropriation of $250 for the beginning of an experiment station has, under advice, been carefully husbanded by me after the failure of the appropriations asked of the last legislature, in order to insure the continuation of the home work.

Fortunately the legislature of 1877 gave him $5,000 for two years and the legislature of 1879 gave $5,000 a year for two years, of which he says, in his report for 1880, "it barely enables us to pay running expenses, and farther improvement and increase of scope will be impossible"; for he then had half a dozen field and laboratory assistants to provide for. At the same time, however, that his local patrons and employers were wondering how Hilgard could use $2,500 for expense money, the United States gave him not less than $25,000 to spend in his cotton work.

The stand taken by Hilgard with reference to the dignity and pedagogical value of agricultural science, while so many institutions, now great, were in their formative periods, was recognized as sound throughout this country and beyond. Set forth in his early reports, it exercised a profound influence. The proper relation of agricultural practise to agricultural science, as factors in educational effort; the educational distinction between labor performed for enlightenment and labor prescribed to beget a liking for labor; the place of both the art and science of agriculture in a university of higher learning, when both are handled ably for instructional purpose—these were among his fundamental contentions, upholding them through many controversies, and his victory is seen in their entry into the regular curricula of all of the newer institutions of learning and their pursuit by older institutions established upon other standards of learning before the existence of these educational factors was dreamed of as worthy and capable.

Hilgard's strategic diversion of 1879 to 1883 was one of the brightest and most effective movements of his career. On the basis of his work in Mississippi he was requested by the director of the census of 1880 to take full charge of the cotton investigations for that census and to do something greater for the cotton industry than was ever done before and he was promised funds for inquiry, investigation, laboratory work and whatever else he deemed necessary to get at the fundamental facts and principles connected with cotton growing in the United States. He reviewed the subject as a whole and in divisions, studied each cotton state and finally, after four years of work, produced in two volumes his report upon the cotton industry of the United States, a lasting benefit to all cotton-producing states. This report, in two quarto volumes, was a force in engrafting original research upon the instructional work, established through the educational land-grant law of Morrill, by the enactment of the Hatch law for state experiment stations in all states.

The results of Hilgard's labors are in the warp of California's first half-century of intellectual and industrial life. He was quick to see his opportunities for public service, to recognize his duty therein and he was masterful and tireless in pursuit of it. He was bold in conquest of truth and fearless in his use of it for the interest of mankind, seizing gladly the smallest fact from research and pressing it to the humblest service but always perceiving and enforcing the relations of both the fact and the service to the broadest interests of his states and of his fellow men. Thus all came to know him as richly wise, unswervingly true, and deeply patriotic and humanistic—a man whose thinking was as clear and whose motives were as unselfish as his service of them was forceful and effective.

E. J. Wickson

University of California

THE SCIENTIFIC WORK OF EUGENE WOLDEMAR HILGARD

Eugene W. Hilgard accepted the position of assistant state geologist of Mississippi in 1855, at the age of twenty-two, but was well equipped for scientific investigations of any kind. He had spent his early boyhood days on a farm, giving his spare hours to the reading of standard works on chemistry and botany and in making collections of plants and insects; then in later years had completed his

scientific training at Heidelberg, Zurich and Freiberg, taking for his graduating thesis the candle flame, in which he was the first to define four parts and to give the chemical processes in each. Thus well trained in the natural sciences, especially in physics, chemistry, botany and geology, with a keen mind, quick and accurate in his observations, and with a remarkable memory, he entered upon the work of the survey with enthusiasm, although the field seemed very unpromising from a geologist's standpoint. He traveled over the state with the state geologist, making observations and collecting material for study. The state geologist, however, failed to make a satisfactory report to the legislature and the survey was suspended, Hilgard returning to Washington as chemist in the laboratory of the Smithsonian Institution and lecturer on chemistry in the National Medical College. In 1858 he was appointed state geologist of Mississippi and resumed his detailed investigations of the geology, botany and agriculture of the state.

One of the chief characteristics in Professor Hilgard's nature was the extreme care, accuracy and attention to detail that he gave to everything he undertook. This is strongly shown in the results of the Mississippi survey, which will ever stand as a tribute to his high standing as a geologist.

Mississippi, because of its large proportion of virgin soils, seems to have been especially well adapted for researches in soil character; and in his geological survey of the state, Hilgard was quick to note the sharply outlined differences in the native tree and plant growth on the several types of soil, and especially the differences in behavior and durability of soils under continued cultivation. He therefore determined to make these the subject of special study in order that the farmers themselves might gain some benefit from the survey. Thus were begun those studies of the chemical, physical and other properties of soils that became his life work, and which, reaching out into other states and other countries, have brought to him honor and renown over the entire civilized world. In 1860 was printed his report on the Geology and Agriculture of Mississippi, a volume of 391 pages in which were given in detail his observations on the geological and agricultural features of the state with chemical analyses of many of the soils. The geological map which accompanied the report also presented the soil divisions which closely followed the geologic changes.

During the civil war Hilgard was placed in charge of the buildings and equipment of the University of Mississippi by the governor, and when its faculty was reorganized at the close of the war he was made professor of chemistry, which title was in 1871 changed to that of professor of experimental and agricultural chemistry; but though relinquishing the position of state geologist to others he continued his interest in the further study of the geology of the state, and of the other southern states. In 1867, at the request of the Smithsonian Institution he made an examination of the Mississippi River delta, the rock salt deposit of Petite Anse Island, and the cause of the formation of the mud-lumps in the passes of the river; and later a geological reconnaissance of Louisiana for the New Orleans Academy of Sciences. The results and discussions of these examinations are published in a number of reports and papers.

Professor E. A. Smith, state geologist of Alabama, says of Professor Hilgard's geological work in Mississippi and Louisiana:

> When in 1855 Dr. Hilgard accepted the position of assistant geologist of Mississippi there began the career of the most distinguished worker in Gulf Coastal Plain Geology, and the fame which he won for himself in this "uninteresting" field is known to all geologists. He has laid the foundation on which most subsequent work in the "Mississippi Embayment," as he named it, securely rests, and after the lapse of more than fifty years since the publication of his report in 1860 his work is appreciated and referred to as authoritative not only by the farmers and other citizens of that state, but by the geologists who have succeeded him.
>
> In the excursions down the Mississippi River and through Louisiana the post-Pliocene of the Port Hudson "stump stratum," and by inference

at least its extension from the Sabine River to Mobile Bay were definitely determined, and the Coast Pliocene of the 1860 map was changed to Port Hudson. The results of these expeditions may be summarized as follows:

1. The outlining of the Mississippi Embayment in Louisiana and Mississippi.

2. The outline geological study and mapping of these two states. He was the first to give a clear and definite account of the origin and distribution of the surface formation which he called the Orange Sand, now known as Lafayette. He was the first to give a definite account of the great series of river and estuarine deposits, "the Grand Gulf," representing all geological time between the Vicksburg and the Lafayette.

3. The recognition of the Cretaceous Ridge, or the backbone of Louisiana, and the determination of the Cretaceous age of the rock-salt and sulphur deposits of Calcasieu parish.

4. The study of the exceptional features of the Lower Mississippi delta and of the mud-lumps and the definite correlation of the Port Hudson formation.

Probably no work has done more for the correlation of the scattered accounts of the geology of the southern states than the Cotton Culture Reports of the Tenth Census prepared under the direction of Dr. Hilgard. In these a summary of the physical and geological features of each state is first given. Then follow accounts of the agricultural features and capabilities of the cotton states, such as would be of interest to immigrants and investors, along with special descriptions of each county, with soil maps and many soil analyses; altogether the reports are reliable handbooks of the cotton states as regards general and agricultural information, and deserve to be more widely known than they are.

On coming to California in 1875 as professor of agriculture in the state university, Hilgard entered upon his greatest field of activity; and from the very beginning, when he laid the strong foundation for the college of agriculture and experiment station of the University of California to the later years when he witnessed the immense results of his labor, he displayed the same remarkable energy, indomitable will and perseverance as well as the hearty comradeship and readiness to help that characterized his work in Mississippi and which gained for him hosts of friends and supporters. He was always ready to give freely of that great and varied store of information of which he was possessed.

Among his California activities there stand out most prominently his studies on humid and arid soils, and especially his researches into the cause, occurrence and effect of alkali salts upon vegetation, and the methods to be used in neutralization and reclaiming alkali land. He was the first to enter upon this field of study, the results of which have been extensively quoted and his bulletins published in other countries where alkali lands exist.

His report on cotton production and the soil regions and soil characteristics of the cotton-producing states, made for the Tenth U. S. Census and comprising two large quarto volumes is a highly valuable work; and his book of about 600 pages on "Soils" is also the highest authority on arid and humid soils.

The mind and hand of Hilgard were never idle, and while engaged in solving old problems in relation to soil fertility and plant life he was ever on the alert for new ones. The results of his activity are shown in the hundreds of published articles in the station reports, outside journals, both foreign and domestic, government publications, etc. During the thirty-five years of active service in the University of California he allowed himself but one vacation of a year and that was spent abroad. A few weeks were given to a survey along the northern transcontinental railroad and a few weeks to a visit to his Mississippi geological locations.

While Hilgard was not the first to make a soil survey and chemical analyses of soils he was the first to interpret the results in their relation to soil durability, fertility and crop production. He was the first to maintain that the physical qualities and chemical characters of a soil go hand in hand in determining its cultural value and he maintained that the complex character of a soil demanded an investigation into its chemical, physical, mineral and biological characters if we would understand it fully. His broad and thorough scientific knowledge, his great work on soils and his valuable publications brought him

many honors, among them the degree of LL.D. from the universities of Mississippi, Michigan, Columbia and California; the Liebig gold medal from Munich, and others from the expositions of Paris, Rio de Janeiro and St. Louis, as well as the offer of Assistant Secretary of Agriculture from President Harrison.

Although much reduced in vitality during the last three years of his life as the result of an injury, his interest and desire for service in the cause of agriculture were keen and virile, and his great regret, daily expressed to the last, lay in his inability to further pursue his studies of soil and other problems.

R. H. LOUGHRIDGE

UNIVERSITY OF CALIFORNIA

THE INDUSTRIAL FELLOWSHIPS OF THE MELLON INSTITUTE

SOME of the important recent events in connection with the operation of the practical system of cooperation between science and industry at the Mellon Institute of Industrial Research of the University of Pittsburgh, have been reported during the past year in this journal. I allude especially to the dedication of the permanent building of the institute,[1] the establishment of a school of chemistry at the University of Pittsburgh,[2] and the inauguration of Professor M. A. Rosanoff as head of the department of research in pure chemistry of the Mellon Institute.[3] In addition, there has been occasion to communicate elsewhere accounts of the graduate school of specific industries of the Mellon Institute[4] and a discussion of the principles involved in the administration of endowed industrial research laboratories.[5] However, almost two years have elapsed since the last report was made to SCIENCE[6] on the status of the system of industrial fellowships initiated by the late Dr. Robert Kennedy Duncan at the University of Kansas and later, on September 1, 1911, transferred to the University of Pittsburgh.

The progressive growth in both the number of industrial fellowships in operation and in the amounts subscribed for their maintenance, is shown in the following table.

Academic Year	Number of Fellowships in Operation	Number of Fellows	Amounts Subscribed for the Maintenance of Fellowships
1911–12........	11	23	$39,700
1912–13........	16	30	53,500
1913–14..	15	29	59,100
1914–15........	24	42	74,350

It is of interest to note that when the industrial fellowship system passed out of its experimental stage—when the Mellon Institute moved into its permanent home in February, 1915—twenty-three fellowships were in operation. At the present time (March 1, 1916) there are thirty-six fellowships and two additional ones have recently been arranged for, to begin later in the year. Sixty-three industrial fellows are engaged on the fellowships now in operation. The growth of the institute has about reached the stage where we shall be obliged to decline further industrial investigations for the present, since our laboratories are almost filled up to capacity.

A LIST OF THE INDUSTRIAL FELLOWSHIPS IN OPERATION AT THE MELLON INSTITUTE ON JANUARY 1, 1916

No. 19: Aluminum.—$5,000 a year for two years; $5,000 a year for the third year. Bonus: $10,000. Fellows: Lester A. Pratt, Ph.D. (University of Pittsburgh); Hugh Clark, Ph.D. (University of Pittsburgh); F. D. Shumaker, B.S. (University of Pittsburgh). (June 1, 1913.)

No. 28: Fertilizer.—$2,500 a year for three years. Bonus: $5,000. Fellow: Earl S. Bishop, M.A. (University of Nebraska). (January 5, 1914.)

[1] Hamor, SCIENCE, N. S., 41 (1915), 418. See also Hamor, *J. Ind. Eng. Chem.*, 7, 326; *Met. Chem. Eng.*, 13, 266, and *Eng. Min. J.*, 99, 480.

[2] SCIENCE, N. S., 42 (1915), 491. See also *Met. Chem. Eng.*, 13, 782; *J. Ind. Eng. Chem.*, 7, 1,002, and *Univ. Pgh. Bull.*, 11, No. 23.

[3] Hamor, SCIENCE, N. S., 42 (1915), 636. See also Bogert, *ibid.*, 737.

[4] Bacon, *J. Ind. Eng. Chem.*, 7, 343; *J. Frank. Inst.*, November, 1914, 624.

[5] *J. Soc. Chem. Ind.*, 35 (1916), 18–27.

[6] Duncan, SCIENCE, 39 (1914), 672.

No. 34: Fatty Oils.—$2,100 a year for two years. Fellow: Leonard M. Liddle, Ph.D. (Yale). (July 1, 1914.)

No. 43: Laundering.—$1,800 a year for one year. Fellow: Harvey G. Elledge, B.S. (University of Kansas). (February 15, 1915.)

No. 44: Land Development.—$1,000 a year for one year. Fellow: Will E. Vawter, B.S. (University of Kansas). (February 1, 1915.)

No. 45: Copper.—$2,000 a year for one year. Fellow: Albert S. Crossfield, B.S. (University of California). (April 19, 1915.)

No. 46: Organic Synthesis.—$6,000 a year for one year. Bonus: $5,000. Fellows: Harold Hibbert, D.Sc. (Victoria University), Senior Fellow; H. A. Morton, Ph.D. (University of Pittsburgh); H. J. Little, B.S. (Delaware College). (July 1, 1915.)

No. 47: Soda.—$3,000 a year for one year. Fellow: C. W. Clark, Ph.D. (University of Pittsburgh). (September 7, 1915.)

No. 48: Bread.—$6,500 a year for two years. Bonus: $10,000. Fellows: Henry A. Kohman, Ph.D. (University of Kansas), Senior Fellow; Truman M. Godfrey, B.S. (University of Kansas); Lauren H. Ashe, B.S. (University of Pittsburgh). (March 1, 1915.)

No. 49: Candy.—$1,800 a year for one year. Fellow: C. A. Neusbaum, A.B. (Wabash College). (July 1, 1915.)

No. 50: Paint.—$1,500 a year for one year. Fellow: J. V. Thompson, A.B. (Cornell University). (September 1, 1915.)

No. 51: Yeast.—$2,800 a year for two years. Fellow: Ruth Glasgow, M.S. (University of Illinois). Scholar: T. A. Frazier (University of Pittsburgh). (September 1, 1915.)

No. 52: Ores.—$5,400 a year for one year. Fellows: Harry P. Corliss, Ph.D. (University of Pittsburgh); C. L. Perkins, B.S. (New Hampshire College); C. L. Weirich, M.S. (University of Pittsburgh). (July 1, 1915.)

No. 53: Copper.—$3,600 a year for one year. Fellows: Charles O. Brown, A.M. (Cornell University); Ernest D. Wilson, Ph.D. (University of Chicago). (July 1, 1915.)

No. 54: Dental Supply Trade.—$2,300 a year for one year. Bonus: royalty. Fellow: C. C. Vogt, Ph.D. (Ohio State University). Adviser: H. E. Friesell, Dean, Dental School, University of Pittsburgh. (July 1, 1915.)

No. 55: Pharmaceutical Products.—$13,000 a year for one year. Fellows: J. R. Watson, B.Sc. (London University); R. A. Dunphy, Ph.D. (University of Pittsburgh); H. W. Huntley, M.A. (University of Wisconsin); J. B. Churchill, B.S. (Harvard); R. N. Mullikin, Ph.D. (Johns Hopkins); E. P. Wightman, Ph.D. (Johns Hopkins); R. W. Harris, M.S. (Ohio State University). (July 7, 1915.)

No. 56: Soap.—$2,000 a year for one year. Fellow: Ben H. Nicolet, Ph.D. (Yale). (June 26, 1915.)

No. 57: Glue.—$1,800 a year for one year. Fellow: Ralph C. Shuey, B.S. (University of Kansas). (July 1, 1915.)

No. 58: Industrial Engineering.—$2,000 a year for one year. Fellow: Rudolph McDermet, M.S.E.E. (University of Illinois). (September 1, 1915.)

No. 59: Milling.—$2,500 a year for one year. Fellow: H. C. Holden, M.S. (New Hampshire College). (September 1, 1915.)

No. 60: Collars.—$2,300 a year for one year. Fellow: H. D. Clayton, B.A. (Ohio State University.) (October 1, 1915.)

No. 61: Synthetic Inorganic Chemistry.—$6,000 a year for two years. Bonus: $3,500. Fellow: Charles S. Palmer, Ph.D. (Johns Hopkins). (October 15, 1915.)

No. 62: Gas.—$6,500 a year for one year. Fellows: James B. Garner, Ph.D. (University of Chicago), Senior Fellow; J. E. Underwood, M.A. (Wabash College); F. W. Padgett, M.S. (University of Pittsburgh). (September 15, 1915.)

No. 63: Peas.—$1,200 a year for one year. Fellow: E. H. Taylor, M.S. (University of Illinois). (November 1, 1915.)

No. 64: Petroleum.—$10,000 a year for one year. Bonus: $10,000. Fellows: B. T. Brooks, Ph.D. (University of Göttingen), Senior Fellow; I. W. Humphrey, B.S. (University of Kansas); Harry Essex, Ph.D. (University of Göttingen); D. F. Smith, M. S. (University of Wisconsin). (September 1, 1915.)

No. 65: Compound Fats.—$2,800 a year for one year. Fellow: Edmund O. Rhodes, M.S.

(University of Kansas). Scholar: R. Lee Wharton (University of Pittsburgh). (October 1, 1915.)

No. 66: Glycero-Phosphates.—$1,500 a year for one year. Bonus: 10 per cent. of profits. Fellow: Frank F. Rupert, Ph.D. (Mass. Inst. Tech.). (October 1, 1915.)

No. 67: Glass Bottles.—$2,100 a year for one year. Fellow: John F. W. Schulze, Ph.D. (Clark University). (December 1, 1915.)

No. 68: Illuminating Glass.—$900 a year for two years. Fellow: A. H. Stewart, A.B. (Washington & Jefferson). (October 1, 1915.)

No. 69: Linoleum.—$2,500 a year for one year. Fellow: Lester E. Cover, B.S. (Pennsylvania State College). (November 1, 1915.)

No. 70: Gum.—$2,500 a year for one year. Bonus: $6,000. Fellow: M. A. Gordon, B.S. (Cornell University). (November 15, 1915.)

No. 71: Stoves.—$2,300 a year for one year. Fellow: A. E. Blake, M.S. (University of Pittsburgh). (October 20, 1915.)

No. 72: Copper.—$6,500 a year for one year. Fellows: E. R. Weidlein, M.A. (University of Kansas); G. A. Bragg, B.S. (University of Kansas). (November 1, 1915.)

No. 73: Illumination.—$6,000 a year for one year. Bonus: $5,000. Fellows: George O. Curme, Ph.D. (University of Chicago), Senior Fellow; H. B. Heyn, B.S. (University of Wisconsin); Glen D. Bagley, M.S.E.E. (University of Illinois). (November 15, 1915.)

No. 76: Coal Tar Products.—$11,000 a year for one year. Fellows: R. R. Shively, Ph.D. (University of Pittsburgh); F. R. Peters, A.B. (Wabash College). (Three more Fellows to be appointed.) (December 1, 1915.)

Special Research Work.—R. P. Rose, M.S. (University of Kansas); R. W. Miller, M.S. (Kansas State College).

The conspicuous success which has attended the development of the system of service to industry founded by Dr. Duncan may be attributed to several factors. First among these, however, is the research strength of the Mellon Institute; this investigative power has resulted from the facilities for research and has been developed by the administrative staff. It has inspired an abiding confidence among industrialists and has eventuated in the consequent renewal, year after year, of industrial fellowships in fields which require constant inquiry, such as those represented by the fellowships numbered 19, 48, 51, 52, 53, 54, 57, 58, 64, 67, 68 and 72.

Several of the multiple fellowships—ones which have the intensive services of two or more researchers under the direction of a senior fellow—established at the Mellon Institute have been effectively at work since the foundation of that institution, and a number of investigations utilizing the services of one man—individual fellowships—have been promoted continuously for the past three years. Thus, although this must be regarded as a very short interval in the career of an institution whose history should be measured by decades, it has been long enough to afford opportunities for the development of ideas and ideals concerning the conduct of industrial research. The practical results of the research experience of the Mellon Institute are rich in applicable instruction and should be useful to the independent organizations which will probably enter the field of industrial research in the near future.

The proposal has been made to establish state industrial research bureaus, to be conducted along the same general administrative lines as the various agricultural experiment stations, and some progress has, in fact, been made in this direction, for the University of Kansas has, in its department of chemistry, a division of state chemical research. Then, too, the Royal Canadian Institute has lately inaugurated a bureau of scientific and industrial research, based upon the system in operation at the Mellon Institute, and several educational institutions are contemplating similar steps in England.[7] The experience of the industrial research institutions now in operation, which is certain to be drawn upon heavily in the movement to make the research work of the

[7] For English appreciations of the system of industrial research in operation at the Mellon Institute, see Sir William Ramsay and G. G. Henderson, *J. Soc. Chem. Ind.*, 34, 751 and 753; and Humberstone, *Quart. Rev.*, 224, Nos. 445, 521.

country national in both scope and effort, should be readily available for use by their prospective allies. Their entrance into this field should be warmly welcomed. No greater good fortune could come to the Mellon Institute, for example, than a division of labors with a number of similarly well-founded establishments.

In keeping with this attitude of welcome towards prospective industrial research organizations, it is important to add that with them no relations can be stable and helpful, but relations of reciprocity. Cooperation is just as essential among research laboratories as it is among the members of a research team. I may therefore be permitted to indicate one serious danger in connection with the establishment of industrial fellowships which is of concern to the Mellon Institute, and that is the danger that, in order to obtain fellowships, the heads of research departments will "let down the bars." In other words, that they will modify the conditions under which industrial fellowships are accepted at the Mellon Institute. This would be a very serious matter and might lead ultimately to the failure of the whole plan.

The administration of the Mellon Institute is now constituted as follows:

Raymond F. Bacon, Ph.D., director;
Samuel R. Scholes, Ph.D., assistant director;
E. Ward Tillotson, Jr., Ph.D., assistant director;
John J. O'Connor, Jr., M.A., assistant director;
William A. Hamor, M.A., assistant to the director;
Martin A. Rosanoff, Sc.D., head of the department of research in pure chemistry.

RAYMOND F. BACON

THE NEW JERSEY MOSQUITO ASSOCIATION

THIS organization, which has for its object the elimination of the mosquito from the standpoint of human comfort and the attendant property values, held its third annual meeting on February 17 and 18. As might be expected from its purpose the membership is composed of business and professional men of all sorts. To become a member it is merely necessary to inform the proper persons that one wishes to become connected with the movement. No dues or assessments are levied upon the individual members and the necessary expenses are borne by the organizations which belong to it.

The program of this meeting included five speakers, who were professionally connected with the practical work; eleven who were identified with it as members of directing boards; two who were responsible for the state work and the correlation of the work of the county units; three who represented the taxpayers who received the benefits and pay the bills; one who represented the Interstate Anti-mosquito Committee; and one who represented the mosquito work of the country as a whole.

One member of the first group, Mr. James E. Brooks, showed that dikes, tide gates, and trenching drain shut-in areas of salt marsh, which the ordinary trenching will not protect, in such a fashion that no serious emergence of mosquitoes takes place. Another member, Mr. William Delaney, pointed out that pumps are necessary on certain enclosed marshes that have shrunken below the sea level, and that a twelve-inch, low-head, motor-driven, centrifugal pump with necessary trenching removed the water from 800 acres of bad breeding marsh in such a fashion that no serious emergence could occur.

Another member of this group, Mr. Harold I. Eaton, showed that the average acre cost of salt-marsh trenching for 12,000 acres drained in the last three years was $4.00, and that the price exclusive of administration expense had been reduced from $5.22 in 1913 to $2.75 in 1915. Another member, Mr. Russell W. Gies, showed that the average per capita cost of county-wide mosquito control work was about 12 cents. Another, Mr. John Dobbins, pointed out the methods, which four years' experience in the practical work had proved to be best for fresh water mosquito control.

The members of the second group, Dr. Wm. Edgar Darnall, Mr. E. B. Walden, Mr. Joseph Camp, Mr. Spencer Miller, Dr. H. H. Brinkerhoff, Mr. Chas. Deshler, Mr. Ira Barrows, Mr.

Walter Hudson, Mr. Robert F. Engle and Mr. Louis J. Richards, confined their statements to the status of the practical work in the counties which they represented.

The first member of the third group, Dr. Jacob G. Lipman, pointed out the tremendous agricultural and urban development which awaits the satisfactory control of the mosquito pest. The second, Dr. Thomas J. Headlee, pointed out the various problems of the New Jersey mosquito's natural history and control that have been recently solved and some of those which still await solution.

The members of the fourth group, Mr. Thomas Mathias, Mr. E. Morgan Barradale and Mr. John N. Cady, devoted their attention to the results of the work (which they said were good) and the esteem (which they said was high) in which it is held by those who pay the bills.

Dr. Haven Emerson, commissioner of health for New York City, and member of the fifth group, outlined the work of this committee as one of correlating the mosquito control work of Connecticut, New Jersey and New York.

Dr. L. O. Howard discouraged the use of bats as a means of mosquito control in New Jersey on the ground that natural conditions did not favor the attempt. He set forth the work of King, connecting *Anopheles punctipennis* Say with the carriage of malaria and gave a brief account of the bureau's work against the malarial mosquito in the lower Mississippi valley.

The following officers were elected for the ensuing year: *President*—Wm. Edgar Darnall, M.D., Atlantic City; *First Vice-president*—H. H. Brinkerhoff, M.D., Jersey City; *Second Vice-president*—Robert F. Engle, Beach Haven; *Secretary-Treasurer*—Thomas J. Headlee, Ph.D., New Brunswick.

The proceedings will be published.

REPORT OF THE PACIFIC COAST SUBCOMMITTEE OF THE COMMITTEE OF ONE HUNDRED ON RESEARCH

The Pacific Coast Subcommittee, appointed in the spring of 1915 by the Committee of One Hundred on Research, has held three meetings. The policy which the subcommittee hopes to follow is expressed in a statement adopted at the first meeting:

1. The relation of advances in pure and applied knowledge to intellectual and economic progress and to good government should be made clear to individuals and to communities at every opportunity.

2. The publication of timely and accurate popular articles making known to the people the results of research should be encouraged.

3. The committee should be informed concerning researches now in progress in the Pacific region. This information need not be carried to extreme detail.

4. The committee should lend assistance to investigators who are handicapped in any way. In special cases it may be possible to assist with grants of money from the American Association, or from other sources.

At the last meeting of the committee the following resolutions were adopted:

I. RELATING TO THE PAYMENT OF THE TRAVELING EXPENSES INCURRED BY INVESTIGATORS IN ATTENDING SCIENTIFIC MEETINGS

(*a*) Attendance upon meetings of scientific societies constitutes a necessary element in the life of investigators.

(*b*) The comparative isolation of the Pacific region from other centers of educational activity is a deterrent influence upon many workers in this region.

(*c*) The financial burden laid upon the investigator who would occasionally attend meetings in the eastern part of the United States is often too great to be borne out of his income.

(*d*) Experience has shown the wisdom of the practise of certain institutions (in this country, and especially in Europe) in contributing all or a part of the expenses incurred by their officers in attending scientific meetings.

This committee therefore urges upon the governing bodies of the universities and colleges of the Pacific region the adoption of some plan whereby, *in approved cases,* modest

grants of money may be made to enable members of their staffs to attend meetings of standard societies held east of the Rocky Mountains, *initial action* to be taken in each case, on its merits, by a suitable advisory committee of the institution concerned.

II. RELATING TO GRANTING OF SABBATICAL LEAVE ON FULL PAY FOR RESEARCH DUTY

(*a*) Research by a university professor is a function not less important than teaching.

(*b*) It frequently happens that a professor's time and energy are so completely absorbed by the work of teaching that research becomes impracticable.

(*c*) It occasionally happens that a teacher, imbued with the spirit of research, spends his sabbatical vacation at a reduced salary in the pursuit of his researches.

This committee therefore urges upon the governing bodies of the universities and colleges of the Pacific region the inauguration of the practise of granting sabbatical leave on full pay *in approved cases,* based upon the presentation of *a definite program* of work leading to *a printed report* upon its completion, *initial action* to be taken in each case, on its merits, by a suitable advisory committee of the institution concerned.

Among the subjects which have given this committee concern is the responsibility of scientists in the United States for the progress of research during and immediately following the European war. Will the impoverishment of governments curtail the support of science in Europe, or will the demonstrated efficiency of scientific methods induce the governments to maintain scientific research at a sacrifice of something else? Whatever the outcome may be, the obligations of American men and women of science to push forward the boundaries of knowledge are certain to be increased.

(Signed) D. H. Campbell,
W. W. Campbell,
F. G. Cottrell,
E. C. Franklin,
J. C. Merriam,
Chairman of the Subcommittee

SCIENTIFIC NOTES AND NEWS

At the annual meeting of the Washington Academy of Sciences, the following officers for the year 1916 were elected: *President,* L. O. Howard; *Vice-presidents,* J. W. Fewkes, Anthropological Society; M. Carroll, Archeological Society; W. P. Hay, Biological Society; R. H. True, Botanical Society; R. B. Sosman, Chemical Society; J. C. Hoyt, Engineers Society; C. B. Mirick, Electrical Engineers Society; W. D. Hunter, Entomological Society; G. B. Sudworth, Foresters Society; O. H. Tittmann, Geographic Society; T. W. Vaughan, Geological Society; J. D. Morgan, Historical Society; E. Y. Davidson, Medical Society; L. J. Briggs, Philosophical Society; *Non-resident Vice-presidents,* E. C. Pickering, A. G. Mayer; *Corresponding Secretary,* F. E. Wright; *Recording Secretary,* W. J. Humphreys; *Treasurer,* W. Bowie; *Managers, Class of 1919,* G. K. Burgess and C. L. Alsberg.

Officers of the Royal Astronomical Society have been elected as follows: *President,* R. A. Sampson, astronomer royal for Scotland. *Vice-presidents,* Sir F. W. Dyson, astronomer royal; Colonel E. H. Hills, W. H. Maw, H. F. Newall, professor of astrophysics, Cambridge. *Treasurer,* E. B. Knobel. *Secretaries,* A. S. Eddington, Plumian professor of astronomy, Cambridge; Alfred Fowler, professor of astrophysics, Imperial College of Science and Technology. *Foreign Secretary,* Arthur Schuster. *Council,* Sydney Chapman; A. L. Cortie; A. C. D. Crommelin; J. W. L. Glashier; Walter Heath; J. H. Jeans; H. S. Jones; E. W. Maunder; J. W. Nicholson, professor of mathematics, King's College; T. E. R. Phillips; A. A. Rambaut, Radcliffe observer; H. H. Turner, Savilian professor of astronomy, Oxford.

The following officers of the Geological Society of London have been elected for the ensuing year: *President,* Dr. A. Harker; *Vice-presidents,* Sir T. H. Holland, Mr. E. T. Newton, the Rev. H. H. Winwood, and Dr. A. Smith Woodward; *Secretaries,* Mr. H. H. Thomas and Dr. H. Lapworth; *Foreign Secretary,* Sir Archibald Geikie; *Treas-*

urer, Mr. Bedford McNeill. In addition to these officers the members of the new council are: Mr. H. Bury, Professor J. Cadman, Professor C. G. Cullis, Mr. R. M. Deeley, Professor W. G. Fearnsides, Dr. W. Gibson, Dr. F. L. Kitchin, Dr. J. E. Marr, Mr. R. D. Oldham, Mr. R. H. Rastall, Professor T. F. Sibly, Professor W. J. Sollas, Dr. J. J. H. Teall and Mr. W. Whitaker.

THE Vienna School of Technology has conferred its honorary doctorate of engineering on Professor Alexander Bauer, formerly professor of chemistry there, who recently celebrated his eightieth birthday.

DR. R. WILLSTÄTTER, professor of chemistry at Berlin, has been elected a foreign member of the Swedish Academy of Sciences.

AT the conclusion of the present semester Dr. Hasse, professor of anatomy in Breslau since 1873, will retire from active service.

DR. ALONZO E. TAYLOR, Rush professor of physiological chemistry at the University of Pennsylvania, sailed on March 11 for Germany where he will engage in Red Cross work as an attaché of the American embassy at Berlin.

DR. JOSEPH A. BLAKE, formerly professor of surgery in Columbia University, has been made chief of the surgical center in the Department of the Seine and Oise, placing him in direct control of six military hospitals.

PROFESSOR ARTHUR G. MCCALL, of the Ohio State University department of agronomy, has resigned to take charge of the soil investigation work at the Maryland Agricultural Experiment Station, effective at the close of the academic year.

DR. H. E. EHLERS, professor of experimental engineering, in the University of Pennsylvania, has been appointed assistant chief of the bureau of engineering of the Pennsylvania Public Service Commission. During the remainder of this semester Dr. Ehlers will spend two days of each week at the university.

DR. LEONARD T. TROLAND, who received appointment at Harvard University to the Sheldon (non-resident) fellowship for the year 1915–16, is spending the year in Nela Research Laboratory. Mr. George P. Luckey, who has spent the past two years in graduate work at Göttingen University, has been appointed Charles F. Brush fellow in physics in Nela Research Laboratory for the year 1915–1916.

DR. J. D. FALCONER, lecturer in geography in Glasgow University and Swiney lecturer in geology at the British Museum, has been appointed temporary assistant district officer in the northern provinces of Nigeria.

PRESIDENT CHARLES R. VAN HISE, of the University of Wisconsin, lectured under the auspices of the Sigma Xi Society at the University of Minnesota on March 17. The subject of the lecture was "The Panama Canal, with Especial Reference to the Slides." President Van Hise is chairman of the commission appointed at the request of President Wilson by the National Academy of Arts and Sciences to investigate the slides, and has recently returned from a trip to Panama.

A MEETING of the Washington Academy of Sciences was held in the auditorium of the New National Museum on March 23, when Dr. L. H. Baekeland delivered an illustrated address entitled "Chemistry in Relation to the War."

AT the meeting of the Michigan Academy of Sciences this week, Professor Ernst A. Bessey, professor of botany at the Michigan Agricultural College, and president of the academy, gives an address on "The Sexual Cycle in Plants." Dr. Charles D. Davenport, director of the Station for Experimental Evolution of the Carnegie Institution, lectures on "The Relation of Juvenile Promise to Adult Performance."

A COURSE of eight lectures on "Problems and Methods in Dynamic Psychology," by Professor Raymond Dodge, is being given at Columbia University on Mondays and Tuesdays from March 27 to April 18.

BEFORE the department of geology of Columbia University a series of lectures on the "Nature and Bearings of Isostasy" is being de-

livered by Dr. Joseph Barrell, professor of structural geology in Yale University.

Dean Shenehan, of the College of Engineering of the University of Minnesota, lectured on March 20 and 21 to the engineering students of Purdue University.

Dr. Charles P. Steinmetz has completed arrangements with Provost Smith for the lecture course by professional engineers under the joint auspices of the Illuminating Engineering Society and of the university, to be held at the University of Pennsylvania in September, 1916.

The alumni of the Michigan College of Mines are raising an endowment fund for the college, to be known as the "George A. Koenig Memorial Fund." Dr. Koenig was from 1892 to 1914 professor of chemistry at the college.

Foreign papers announce the death of E. W. Pawlow, the Russian surgeon. It may be that the death of Ivan Pawlow, the physiologist of the St. Petersburg Academy of Sciences, cabled to this country and printed in Science, was an error due to confusion with E. W. Pawlow.

Charles Jeptha Hill Woodbury, a widely known engineer of Boston, died on March 20, aged sixty-four years.

John Wesley Judd, F.R.S., professor of geology from 1876 to 1905 and dean of the Royal College of Science, London, for the last ten years of that period, died on March 3, at the age of seventy-six years.

Dr. Ernst Mach, emeritus professor of the history and theory of inductive science at Vienna, has died at the age of seventy-eight years.

The deaths are also announced of Professor E. Heckel, professor of botany in the University of Marseilles; Professor Vladimir A. Tichomirov, professor of pharmacy and materia medica at Moscow University and Russian Councillor of State; and Dr. Fritz Schmid, since 1889 director of the Swiss Bureau of Health.

The Naples Table Association for Promoting Laboratory Research by Women announces an eighth prize of one thousand dollars for the best thesis written by a woman on a scientific subject. This thesis must embody new observations and new conclusions based on independent laboratory research in biological (including psychological), chemical, or physical science. The theses offered in competition must be in the hands of Dr. Lilian Welsh, Goucher College, Baltimore, Md., before February 25, 1917. The examiners are Dr. William H. Howell, Dr. Elmer P. Kohler and Dr. Henry Crew.

Professor Herbert Osborn, of Ohio State University, director of the Lake Laboratory, Cedar Point, Ohio, will be absent on leave next summer. The acting director will be Dr. F. H. Krecker, of the Ohio State University. Others on the staff will be Professor J. H. Schaffner, Ohio State; Professor S. R. Williams, Miami University; Professor Fullmer, Baldwin-Wallace, and Professor Z. P. Metcalf, of the North Carolina College. The laboratory will open on June 19. The course of instruction will continue until July 28 but the laboratory will be at the disposal of independent workers at least until the middle of August. The laboratory is well situated for the study of the fauna and flora of the Lake Erie region and any biologists interested will be welcomed.

We learn from *Nature* that the third Indian Science Congress met at Lucknow on January 13–15. About seventy papers were read and more than 300 visitors attended the meetings. The presidential address was delivered by Sir S. G. Burrard, F.R.S., who took as his subject "The Plains of Northern India, and their Relationship to the Himalaya Mountains." Sir A. G. Bourne, F.R.S., has been elected president for 1916–17, and the next meeting will probably be held at Bangalore.

A conference on Graduate Medical Education was held at the University of Minnesota on March 15, participated in by members of the graduate faculty at Minneapolis and those connected with the Mayo Foundation, Rochester, Minn. The program was as follows:

Afternoon Session

1. Address by President George E. Vincent.
2. Communication from Dean Guy Stanton Ford.

3. "General Requirement of the Graduate School," Dr. C. M. Jackson.

4. "The Thesis Requirement," Dr. J. B. Johnston; Dr. A. H. Logan.

5. "Methods of Graduate Instruction," Dr. E. P. Lyon.

Evening Session

6. Symposium on special requirements for the degree of doctor of science in various medical specialties (including desirable pre-requisites).

(*a*) "Medicine," Dr. L. G. Rowntree; Dr. H. S. Plummer.

(*b*) "Pediatrics," Dr. J. P. Sedgwick.

(*c*) "Surgery," Dr. J. E. Moore; Dr. E. M. Beckman.

(*d*) "Obstetrics," Dr. J. C. Litzenberg.

(*e*) "Eye, Ear, Nose and Throat," Dr. F. C. Todd; Dr. Carl Fisher.

(*f*) "Nervous and Mental Diseases," Dr. A. S. Hamilton.

(*g*) "Pathology and Bacteriology," Dr. L. B. Wilson; Dr. H. E. Robertson.

A stenographic record of the proceedings was kept and will perhaps be printed. If not, several copies will be available for the perusal of those interested in the development of graduate clinical instruction.

The Forestry Club at the New York State College of Forestry at Syracuse University is giving for the season of 1915–16 the following lectures:

December 16—"The Story of the Forest," by Frederick E. Clements, chief, department of botany, University of Minnesota, and state botanist of Minnesota.

January 13—"The Development of a Forest Service for Minnesota," by William T. Cox, state forester of Minnesota.

January 18—"Close Utilization of the Products of the Forest," by W. R. Brown, of the Berlin Mills Co., Berlin, N. H.

January 27—"The Birth of a Forest Policy," by B. E. Fernow, dean, faculty of forest, University of Toronto, Toronto, Canada.

February 3—"Forestry and the Business Development of the Country," by Elmer E. Hole, editor, *American Lumberman*, Chicago, Ill.

February 17—"A Better Place to Live," by Frank A. Waugh, chief, department of horticulture, Massachusetts Agricultural College, Amherst, Mass.

February 24—"Forestry in New York," by James S. Whipple, former forest, fish and game commissioner of the state of New York, Salamanca, N. Y.

March 2—"The Vegetation of the United States as Influenced by Glacial Action," by Henry C. Cowles, of the University of Chicago.

March 9—"Modern Forest Utilization," by R. S. Kellogg, secretary, National Lumber Manufacturers Association, Chicago, Ill.

March 23—"State-wide Fire Protection for the Woodlots and Forests of New Hampshire," by E. C. Hirst, state forester of New Hampshire.

March 30—"Combating Insects of the Orchard and Forest in New York State," by George G. Atwood, chief, bureau of horticulture, New York State Department of Agriculture, Albany, N. Y.

April 6—"Shade-tree Work in Buffalo," by Harry B. Filer, city forester of Buffalo, N. Y.

The following lectures are scheduled to be given before the Franklin Institute in Philadelphia:

March 23—"Recent Developments in Electrical Apparatus," by Harold Pender.

March 30—"Some Problems in Physical Metallurgy at the Bureau of Standards," by George K. Burgess.

April 6—"Use of Powdered Coal in Metallurgical Processes," by C. J. Gadd.

April 13—"Heat Measurements as Related to the Industries," by Charles W. Waidner.

April 19—"Scientific Research in Relation to the Industries," by Charles P. Steinmetz.

A bequest of $25,000 has been made to the Cleveland Medical Library by the will of Dr. Benjamin L. Millikin, former dean and senior professor of ophthalmology of the Western Reserve Medical School.

UNIVERSITY AND EDUCATIONAL NEWS

The wills of the late Edith and Walter Scull, niece and nephew of David Scull, for many years a manager of Haverford College, give $100,000 to the college.

The trustees of Columbia University, at their last meeting, decided to admit women to the medical school as soon as the equipment made the step practicable.

At Harvard University assistant professors have been appointed as follows: Grinnell

Jones, S.B. (Vanderbilt), chemistry; Elliott G. Brackett, M.D. (Harvard), orthopedic surgery, and Frederick H. Verhoeff, Ph.B. (Yale), ophthalmological research.

Dr. Otto Diels, of Berlin, has been called to the chair of chemistry at Kiel. Dr. R. Pohl, docent in Berlin, has been called to an associate professorship of physics at Göttingen.

DISCUSSION AND CORRESPONDENCE

DID SPENCER ANTICIPATE DARWIN?

In his book, entitled "The First Principles of Evolution," Mr. S. Herbert in speaking of Herbert Spencer says:

> Not only was he the first independently to adopt the evolutionary principle as a means of the solution of various problems of matter and mind, actually anticipating Darwin's discovery by a few years—a fact very little known by the general public—but he gradually elaborated a complete theory of evolution, comprising in one great formula the law of all existence.[1]

This statement, except the latter part of it, may hardly be said to be in conformity with the facts. When we remember the eminent services of Lamarck in the application of the evolutionary principle in his "Philosophie Zoologique" published in 1809, and subsequently (1815) in his "Histoire Naturelle des Animaux sans Vertèbres," it seems hardly fair to ascribe priority to Spencer in the adoption of the evolutionary principle, or even in adopting it "as a means for the solution of various problems of matter and mind"; and so far as Spencer anticipating Darwin is concerned, it is certainly incorrect, if by Darwin's discovery we understand, as most people do, the principle of natural selection.

It is true, of course, that as early as 1852, seven years prior to the publication of the "Origin of Species," Spencer presented with a clearness not since surpassed, the evolutionary hypothesis; and that in 1855 he published his "Psychology," which assumed the correctness of the broad evolutionary doctrine. But evolution and Darwin's discovery, as of course Mr. Herbert well knows, are quite different things.

In his autobiography, Vol. II., p. 56, Mr. Spencer says:

> Up to that time (1859) or rather up to the time in which the Linnean Society had become known to me, I held that the sole cause of organic evolution is the inheritance of functionally produced modification. "The Origin of Species" made it clear to me that I was wrong; and that the larger part of the facts can not be due to any such cause.

In an essay on "Transcendental Physiology," first published in 1857, Spencer used the following language:

> Various facts show that acquired peculiarities resulting from the adaptation of constitution to conditions, are transmissible to offspring. Such acquired peculiarities consist of differences of structure of composition in one or more of the tissues. This is to say, of the aggregate of similar organic units composing a germ, the group going to the formation of a particular tissue will take on the special character which the adaptation of that tissue to new circumstances had produced in the parents. We know this to be a general law of organic modifications. Further, it is the *only* law of organic modifications of which we have any evidence.[2]

Spencer himself instances this passage as showing the stage of his thought at that time concerning the factors of evolution. It will be observed that there is not the slightest hint of natural selection.

Again in his "Principles of Biology," Vol. I., p. 530, Mr. Spencer uses for the first time the phrase "survival of the fittest," as a substitute for "natural selection." In a footnote he explains why he sometimes uses the phrase "natural selection" after he had suggested the expression "survival of the fittest," and this expression had been approved by Wallace as a substitute for the other. He says:

> The disuse of Dr. Darwin's phrase would have seemed like an endeavor to keep out of sight my own indebtedness to him and the indebtedness of

[1] Herbert, S., "The First Principles of Evolution," p. 4, London, 1913.

[2] Spencer, H., "Essays," Vol. I., p. 91.

the world at large. The implied feeling led me ever since to use the expressions "natural selection" and "survival of the fittest" with something like equal frequency.

In the same volume, page 531, in referring to "natural selection," he says:

This more special mode of action Dr. Darwin has been the first to recognize as an all-important factor, though, besides his co-discoverer, Mr. A. R. Wallace, some others have perceived that such a factor is at work. To him we owe due appreciation of the fact that "natural selection" is capable of *producing* fitness between organisms and their circumstances.

Here we have "Darwin's discovery" specifically pointed out, and Spencer's acknowledgment of his own indebtedness.

Of course, it would have been no great matter even if the idea of natural selection had presented itself to Spencer before Darwin published the "Origin of Species" in 1859. Twenty years prior to that time it had suggested itself to Darwin and, being almost constantly at work on its application, he must have communicated the idea directly or indirectly to many of his friends. In fact he says in the short sketch of his life, prefixed to his "Life and Letters":

I tried once or twice to explain to able men what I meant by natural selection, but signally failed.

Possibly Spencer was one of these "able men."

Of course priority with respect to the idea of natural selection is of comparatively little importance. It flashed upon Darwin's mind, just as it did upon Wallace's, from reading a paragraph in "Malthus on Population." Darwin says:

In October, 1838, that is, fifteen months after I had begun my systematic enquiry, I happened to read for amusement "Malthus on Population," and being well prepared to appreciate the struggle for existence which everywhere goes on from long-continued observation of the habits of animals and plants, it at once struck me that under these circumstances favorable variations would tend to be preserved, and unfavorable ones to be destroyed. The result of this would be the formation of a new species. Here then I had at last got a theory by which to work.

It was with both of these men an original idea, but it was foreshadowed by Aristotle, who, in his "Physicæ Auscultationes" (lib. 2, cap. 8, s. 2) said that:

Whatsoever, therefore, all things together (that is all the parts of one whole) happened like as if they were made for the sake of something, these were preserved, having been appropriately constituted by an internal spontaneity; and whatsoever things were not thus constituted; perished and still perish.

It was clearly recognized by Dr. W. C. Wells, in a paper read before the Royal Society in 1813 entitled: "An account of a white female, part of whose skin resembled that of a negro," and published in 1818. It was stated precisely by Mr. Patrick Mathew in 1831 in his work on "Naval Timber and Arboriculture." Everybody knows the story of how Darwin was "forestalled with a vengeance" by A. R. Wallace. It seems strange, then, that Spencer, who was writing more or less on biological subjects during the many years in which Darwin was at work on the idea of natural selection, does not appear to have gained even an inkling of the idea. He and Darwin were corresponding, and Darwin had complimented him on his admirable discussion of the development theory.

Perhaps the nearest approach of Spencer to the idea of natural selection occurs in an essay entitled "A Theory of Population Deduced from the General Law of Animal Fertility," published in 1852, although Spencer says he entertained as early as 1847, possibly earlier, the idea it embodies. In this essay, after declaring that the pressure of population has been the proximate cause of progress, Spencer goes on to say:

And here it must be remarked that the effect of pressure of population, in increasing the ability to maintain life, and decreasing the ability to multiply, is not a uniform effect, but an average one. . . . All mankind in turn subject themselves more or less to the discipline described; they either may or may not advance under it; but, in the nature of things, only those who do advance under it eventually survive. . . . For as those prematurely carried off must, in the average of cases, be those in whom the power of self-preser-

vation is the least, it unavoidably follows that those left behind to continue the race, are those in whom the power of self-preservation is the greatest—are the select of their generation.

Concerning this passage Spencer says in his "Autobiography," p. 451:

It seems strange that, having long entertained a belief in the development of species through the operation of natural causes, I should have failed to see that the truth indicated in the above-quoted passages, must hold, not of mankind only, but of all animals; and must everywhere be working changes among them.

He attributes his blindness to his belief that the inheritance of functionally produced modifications suffice to explain evolution, and to the further fact that he knew little or nothing about the phenomena of variation.

The great merit of Darwin is, of course, not in originating the idea of natural selection, but in so presenting it to the world that it won acceptance. The fact that others anticipated him so far as the idea is concerned, does not, of course, detract from his merit. Wallace is entitled to much credit for the independent discovery of the idea and its clear presentation, but his anticipation was only in the disposition to proclaim the discovery. The foundation of Darwin's immortality is the book, "The Origin of Species." He was perhaps the only man in the world at the time who could have written that book. We might have attributed the possibility to Wallace, but with a self-abnegation perhaps unparalleled in the history of science, he said:

I have felt all my life and I still feel, the most sincere satisfaction that Mr. Darwin had been at work long before me, and that it was not left for me to attempt to write "The Origin of Species." I have long since measured my own strength and know well that it would be quite unequal to that task. For abler men than myself may confess, that they have not that untiring patience in accumulating, and that wonderful skill in using, large masses of facts of the most varied kind, that wide and accurate physiological knowledge, that acuteness in devising and skill in carrying out experiments, and that admirable style of composition, at once clear, persuasive and judicial, qualities which in their harmonious combination mark out Mr. Darwin as the man, perhaps of all men now living, best fitted for the great work he has undertaken and accomplished.[3]

I. W. Howerth

University of California

THE ATOMIC WEIGHT OF RADIUM EMANATION (NITON)

In the International Atomic Weights Table for 1916,[1] the commission has adopted for radium the value of *226.0,* obtained by Hoenigschmid in 1911.[2] The atomic weight of radium emanation (niton), however, has been retained at its former value of *222.4* instead of substituting *222.0,* which would conform with the new value for radium. The probability of an oversight in publishing the table is perhaps eliminated by the appearance of the same value in the German report.[3]

The retention of the value *222.4* raises a question of considerable interest. The genetic relationship among elements, and the consequent interdependence of the atomic weights of radioactive elements is relatively new, and has as yet been given only indirect recognition in the atomic weight tables (see below). Of the 30-odd new radioactive elements, only radium and radium emanation have as yet been placed in the atomic weight table, since they are the only two which could as yet be obtained in sufficient quantity and purity for the application of ordinary methods of atomic weight determination.

Since no new experimental work has appeared on the atomic weight of niton, the retention of its old value until such work appears might be regarded *a priori* as justified. But it should be recalled that the experimental work of Gray and Ramsay,[4] on which the value *222.4* was based, in reality served only to demonstrate the order of magnitude of the atomic weight and would fit the value *222.0* equally as well as *222.4*. The latter

[3] "Contributions to the Theory of Natural Selection" (1871), preface, pp. iv, v.

[1] *Jour. Am. Chem. Soc.,* 37, p. 2,451.

[2] *Sitzb. Wien Akad.,* 120, p. 1,617; *ibid.,* 121, p. 1,973 (1912).

[3] *Zeit. phys. Chem.,* 90, p. 720.

[4] *Proc. Royal Soc.,* 84 *A*, p. 536.

value was chosen by Gray and Ramsay on purely genetic grounds, in accord with the then accepted value for radium of *226.4*. (The actual average of the experimental results of Gray and Ramsay was *223.0*.) The genetic principle once having been thus recognized in the atomic weight table, it would now appear requisite that the atomic weight of niton should be changed automatically to accord with that of radium. Of course from the standpoint of radioactivity the adoption of this change is automatic, but from the aforementioned considerations regarding the choice of Gray and Ramsay, there appears also no sufficient reason to retain the old value in the Atomic Weights Table.

S. C. LIND

BUREAU OF MINES EXPERIMENT STATION,
FOSTER BUILDING,
DENVER, COLO.

THE BRUCE MEDAL

THE notice of the award of the Bruce medal of the Astronomical Society of the Pacific, as recorded on page 285 of the February 25 issue, contains the first public statement that has come under my notice of the very ingenious method of award of this medal, "probably the most unique in the history of science."

The plan is due to the late Dr. Edward S. Holden, then director of the Lick Observatory, who secured the gift of the fund for this international medal. The plan he devised was designed to preserve the value of the medal as an international honor of high character, in spite of the fact that many of the directors of the society who would determine the awards would not be professional astronomers and often would not be capable of forming independent judgments as to the value to science of the distinguished services. In short, it was his purpose to make practically impossible an award to those who appear to be unable to keep their names out of prominent locations in the daily press. A glance at the list of recipients of the medal as published in your said notice shows how very successfully have worked out the plans thus contrived by him.

While the deliberations of the directors in making these awards are kept strictly confidential, a sidelight or two may be interesting. The rules provide that the six observatories named shall be invited to nominate not more than three men distinguished in astronomy. Ordinarily, this insures eighteen names, only one of which can receive the award; but in reaching the decision the directors often have been guided by the number of times the proposed recipient has been nominated. Occasionally, an elderly nominee, nearing the end of his activities, has been preferred over a younger man with the prospect of useful years ahead of him. It is worthy of note that the lists of every one of the six nominating observatories, for the first award of the medal, contained the name of Simon Newcomb.

One very well-known foreign observatory, however, added weight to its nominations in entirely different fashion. The first year it nominated Newcomb, Auwers and Gill, in the order named. Newcomb was the first medalist. The second year it nominated only Auwers and Gill. Auwers was the second recipient. The third year it nominated Gill alone, and Gill was the third. The fourth year it nominated three.

Only thirteen awards have been made in eighteen years because of the comparatively large sum spent out of the fund in the design and cutting of the dies. Designs were requested from experts both in this country and abroad, and the competition was arranged so that the name of the designer was unknown to the committee. When the designs were opened, although all were of high degree of excellence, one stood out in such contrast that only one choice was possible, and, with certain minor modifications, it was adopted. Alphée Dubois, of Paris, was the successful artist, and during his lifetime he personally engraved on the medals the names of the recipients, the dies being kept in the French Mint for this purpose.

This medal fund is only one of a number of such gifts of the late Miss Bruce, she having contributed frequently to the advancement of science.

ALLEN H. BABCOCK

A CHEAP ROCK POLISHING MACHINE

A small high-speed carborundum wheel, clamped to one of our work tables, has long been used for its obvious purposes. It may interest those geologists and paleontologists who have not stumbled on to the same fact to know that this machine offers a most efficient and rapid method of obtaining a polished section of a rock or a fossil. My attention was first called to this use of the machine during a conference with Mr. Robert Harvie on the organic identification of some obscure markings in a calcareous sandstone. By splitting the rock in an ordinary screw press and holding the desired portion of the exposed face against the side of the wheel, for which purpose there is a convenient rest, three flat sections were made and studied in as many minutes. The method is somewhat crude, but efficient, and may have wide application. A higher polish could be secured by using wheels of differing degrees of fineness.

Lancaster D. Burling

Geological Survey of Canada

THE SMITHSONIAN PHYSICAL TABLES

To the Editor of Science: The Smithsonian Institution has just published a new edition of the Smithsonian Physical Tables, corrected and slightly modified from the sixth revised edition. Requests have come from certain educational institutions for separate copies of certain individual tables for the use of students in laboratories. If there is likely to be a considerable demand for such separates, the institution will have them printed on stiff paper and distributed at cost to those who desire them. With a view to ascertaining the probable demand for separate tables, it is requested that readers of Science inform the institution which tables they would desire in separate form and the number of copies of each they would require. All tables for which the probable demand of this kind reaches 100 copies will be reprinted separately. The tables may be consulted in nearly all of the larger libraries.

C. D. Walcott,
Secretary

SCIENTIFIC BOOKS

Temperatur und Lebensvorgänge. Von Aristides Kanitz. Verlag von Gebrüder Borntraeger, Berlin. s.s. 175 mit 11 textfiguren. 1915.

"Temperatur und Lebensvorgänge" is the first of a series of biochemical mongraphs (Die Biochemie in Einzeldarstellungen), written by specialists, to be published by Gebrüder Borntraeger under the editorship of Aristides Kanitz. The series will treat of biological chemistry in its broadest sense and is comparable to the English monographs on Biochemistry edited by Plimmer and Hopkins.

It has been known for a long time that temperature has a very great influence on life processes, but only within recent years has a quantitative study been made and the values obtained compared with the effect of temperature on various physical and chemical processes. According to Kanitz the first quantitative studies were made by Clausens in 1890 on the carbon dioxide production of seedlings and the results interpreted by van't Hoff in terms of his rule—that the velocity of chemical reactions increases two- to three-fold for every ten degrees rise in temperature. Since that time many quantitative temperature investigations have been carried out with special reference to van't Hoff's rule or the RGT (Reaktionsgeschwindigkeit) rule as Kanitz prefers to call it. These investigations are systematically recorded in the book, which is unusually complete. Often the original data are given and always the value of Q_{10}, which indicates the rate of increase of any physiological process for a 10° C. rise of temperature. References are made to 363 original papers and the book contains both a subject and an author's index, besides a table of contents, so that any subject may be found with the greatest ease. The effect of temperature on various rhythmic processes, as heart beat, breathing, contractile vacuoles and contraction of medusæ; on the rate of the nerve impulse, muscle contraction, electromotive force of bioelectric currents, geotropic and phototropic reactions, protoplasmic streaming, permeability, effect of poisons, the length of life, rate of

growth, and various metabolic processes of plants and animals are all considered. Many observations are of the author's own work and all are discussed with reference to the RGT rule. Indeed, one wishes that the effect of temperature on purely physical processes was more fully considered. There is of course no doubt but that the main effect of temperature on life processes is to be explained in terms of its effect on chemical reactions, nevertheless, there are irregularities in the temperature coefficients of biological processes which must be explained as the result of temperature changing two processes at the same time, and not merely the velocity of some chain of chemical reactions. It is the exception rather than the rule which should now claim the attention of physiologists.

It is always a great convenience to have the results of some one subject of investigation collected and tabulated by a competent investigator and this book will serve as an excellent reference work to the physiologist and biochemist interested in temperature and as a guide to future research along that line.

E. Newton Harvey

Physiological Laboratory,
Princeton, N. J.

Geologia Elementar, preparada com referencia especial aos Estudantes Brasileiros e á Geologia do Brazil. Por John C. Branner. Second edition, Francisco Alves et Cia, 166 Rua do Ouvidor, Rio de Janeiro, Brazil.

The second edition of this excellent handbook, not only for Brazilian students as the title states, but of Brazilian geology, brings up to date in 396 pages of text the matter presented in the first edition of the year 1906. Perhaps no one now living in or outside of Brazil is so well prepared to write a regional geology text of this character as President Branner. The present edition is based upon the first, which was written in English and translated into Portuguese with the collaboration of the late Dr. Derby. The additional matter in the new edition was written in Portuguese by the author, and revised by Doctors Barreto and Lisboa. The subject-matter is systematically set forth with illustrations of local geological peculiarities, among which the magnificent examples of weathered rocks, the coral banks of the coast and sandstone reefs of Pernambuco, the remarkable growths of the mangrove, the geological work of ants, and the striking evidences of a slightly elevated shore-line, form admirable subjects for didactic geology. Where Brazil is now wanting in evidences of important agencies of geological change, the author has very properly, in the interest of the student, introduced striking examples from foreign lands. The North American student of geology, even if he does not read Portuguese, will find the black-line maps illustrating the distribution of the geological formations of Brazil as they are at present known, the most serviceable at his command. The guide fossils representing the chief types in the Brazilian Upper Silurian, Devonian, Jurassic, Cretaceous and Tertiary deposits are set forth in line and stipple drawings which have the merit of distinctness. Numerous cross-sections show the understanding of the geological structure, in particular the coastwise portion of the country. President Branner has embodied the latest discoveries concerning the Permian glaciation in south Brazil, as well as the results of Dr. I. C. White's monographic work upon the "Geology of the Brazilian Coal Field." The footnotes give reference to the more important geological reports on the region, among which must not be forgotten the author's "Bibliography of the Geology of Brazil," in *Bulletin Geol. Soc. Amer.*, Vol. 20, p. 132, 1909.

The geological traveller bound to Brazil will find this work indispensable as a *vademecum,* and an additional incentive to gain command of the Portuguese tongue.

J. B. Woodworth

Irrigation in the United States. By Ray Palmer Teele, M.A. D. Appleton and Company, 1915. Pp. 253.

The conquest by irrigation of the vast area of our country that lies under a low annual rainfall—approximately 20 inches and less—has become a matter of national interest. Our

increasing population needs the foodstuffs that may be produced, abundantly, on the irrigated farms, and the "landless" men want the new farms upon which to build independence for themselves and their families. During the last quarter of a century, public and private capital has been poured into the irrigation enterprises of the Great West; vast tracts have been opened for settlement; serious and difficult problems have arisen, which yet await solution. Thousands of investors, great and small, in all sections of the United States, are holding irrigation securities which in many cases are of doubtful value.

As the importance of land reclamation by irrigation became more fully realized, an irrigation literature of great value was produced, which, however, concerned itself chiefly with the construction of irrigation works, or with the actual use of water on the land. Mr. Teele, in the present volume, has had in mind the needs of the great body of our citizens, wherever they may live, who, because of their interest in irrigation, desire a comprehensive yet non-technical discussion of the meaning, extent, purpose, problems and present status of irrigation in the United States. The present volume is devoted, therefore, to a "discussion of the legal, economic and financial aspects" of irrigation.

The author has accomplished his purpose admirably. After a brief discussion of the irrigated section, with respect to climate, water supply and crops, the author takes up the consideration of legislation relating to irrigation, irrigation investments and the organization and operation of irrigation enterprises. This discussion, though brief, is exceedingly clear and comprehensive, and the reader is left with a vivid picture of the real irrigation situation in our country. Elements of weakness or strength are pointed out and wise suggestions are frequently made for improvement. To the seasoned student of irrigation, the last chapter, on the present situation and future of irrigation in the United States, is of greatest interest, for it includes the author's well-reasoned conclusions concerning the methods of stabilizing the economics of irrigation.

The book should be read and studied by national and state legislators, who have to do with the making of irrigation laws; by the projector of new irrigation enterprises; by the investor; by the man on the irrigated farm, and by all who are interested in the gigantic movement to conquer all of our Great West for the use of man.

Mr. Teele is particularly well fitted to speak with authority on irrigation subjects. Through his editorial hands have passed practically every irrigation publication issued by the U. S. Department of Agriculture since 1899. He is personally familiar with the irrigated section, and is an enthusiastic believer in irrigation, though he has never closed his eyes to its difficulties. Irrigation in its present stage of development needs honest friends.

The survey in this volume is so brief that we hope the author may some time find time to enlarge upon his theme for the technical student. Moreover, we shall not know the full meaning of irrigation until its sociological aspects are examined, and this volume only hints at the conditions of human life under the ditch. Nevertheless, Mr. Teele's book is a great contribution to irrigation advancement in that it brings order out of a confusion of knowledge, and points out the way by which our present irrigation difficulties may be overcome.

John A. Widtsoe

Utah Agricultural College,
Logan, Utah

SPECIAL ARTICLES

ON THE PHYSICAL CHEMISTRY OF EMULSIONS AND ITS BEARING UPON PHYSIOLOGICAL AND PATHOLOGICAL PROBLEMS

I

We have been engaged during the past few months in a study of the conditions which determine the making and the breaking of emulsions. In addition to verifying certain well-known observations, this inquiry has brought some new points of view which are of importance for the theory of the stability of emulsions, and for the solution of such technical and biological problems as are embraced in the making of butter, the preparation of thera-

peutic emulsions, fatty degeneration, the formation of fatty secretions, etc.

Of the long list of mutually immiscible liquids that might have been chosen for a study of emulsification, we have worked chiefly with water and oil. The mixture of two such immiscible liquids may yield two types of emulsions, as Walther Ostwald first showed; one consisting of oil in water, a second, of water in oil. With much water and little oil, the first type of emulsion is usually obtained; with much oil and little water, the second type. When medium amounts of the two liquids are mixed with each other, either type may be produced, depending upon the methods of mixing.

Oil placed in contact with water does not lead spontaneously to the formation of an emulsion. To produce such, the two must be beaten together. The amount of oil that may be emulsified in pure water is very small, in no case exceeding one or two per cent. These emulsions are, however, stabile. The oil particles in such emulsions are rather small, their dimensions lying within the realm of the colloids. These low concentrations of oil in water, therefore, really represent colloid suspensions of oil in water and possess not only the stability characteristics of such systems, but also their well-known "saturation limit."

The term "emulsion" is ordinarily used to cover the subdivision of one fluid in a second in amounts exceeding these low values. The mixture must, moreover, show a fair degree of stability; in other words, the two liquids constituting the dispersoid must not separate in the course of weeks, months or years. A *temporary* subdivision of any quantity of oil in a given volume of water, or the converse, can, of course, be obtained by merely beating the two together.

The problem of emulsification therefore resolves itself into the question of how, once the division of oil in water has been accomplished, this can be, or is, stabilized. Contrary to the general belief of different workers who have each tried to discover some *one* element as responsible for this stabilization, a number of different factors evidently play a rôle, the relative importance of which may not only vary in different emulsions, but in the same emulsion under different circumstances.

It is generally held that the formation and the maintenance of an emulsion depend upon the slight surface tension of the dispersing medium, and its high viscosity. While both these factors undoubtedly play a part, their inadequacy in explaining the stability of all emulsions is generally admitted. Not only does the stability of emulsions not universally parallel the surface tension values of the liquids making up a given dispersoid, but dilute soap solutions with low viscosity act as better emulsifying agents than more viscid glycerin solutions. Pickering has emphasized the importance of a third factor in the maintenance of an emulsion, namely, the development of an encircling film about the droplets of the divided phase through the accumulation in the surface between oil and dispersion medium, of finely divided particles of a third substance. But this explanation, too, seems adequate only for selected examples of emulsions.

II

In reviewing the empirical instructions available for the preparation of emulsions, and in our own attempts to formulate such as would always yield permanent results, we were struck with the fact that their production is always associated with the discovery of a method whereby *the water (or other medium) which is to act as the dispersing agent is all used in the formation of a colloid hydration (solvation) compound.* In other words, when it is said that the addition of soap favors the formation and stabilization of a division of oil in water, it really means that soap is a hydrophilic colloid which, with water, forms a colloid hydrate with certain physical characteristics, and that the oil is divided in this. *The resulting mixture can not, therefore, be looked upon as a subdivision of oil in water, but rather as one of oil in a hydrated colloid.*

The amount of colloid necessary for stabilization, at least in the preparation of an emulsion, is rather great. It must be sufficient to

bind all the water. The concentrated soaps show a high degree of water-absorbing power and so are among the best emulsifying agents. Very good, too, are blood-albumin, casein, egg-white and egg-yolk, this last already representing an emulsion of oil in a hydrated protein. Good emulsions may also be prepared with aleuronat, and, when the temperature is properly controlled, with gelatin. Not only may proteins be thus used, but various hydratable carbohydrates do well. Acacia has long been so used. Starch, dextrin (or the dextrinized starches used in baby foods), and, when the temperature is properly regulated, agar, also serve well. Oil can also be maintained in finely subdivided form in cane sugar solutions or glycerin, but these emulsions slowly separate.

The enumerated substances do not all act equally well. This is because, in the production of a hydrated colloid, they behave differently from both a qualitative and quantitative viewpoint. Best results are obtained with those substances which not only have the power of taking up much water, but which yield liquids of good viscosity with all amounts of water that may be added to them. What is wanted is a relatively homogeneous liquid of good tenacity, by which is meant one that possesses good covering power together with great cohesiveness.

The action of casein as a stabilizing agent is particularly instructive. Neutral casein does not absorb much water and it does not in this form serve for the preparation of an emulsion. But when alkali is added, it develops marked hydrophilic properties, on the appearance of which it becomes one of the best stabilizing agents for emulsions known. It might be thought that the alkali element is so important because it forms a soap in contact with oil, and soap has long been known as an effective emulsifier. While some such action no doubt occurs, it is easily proved that the development of hydrophilic properties by the casein is of first importance because acid (which when added to neutral casein converts it into a hydrophilic colloid) works quite as effectively as does alkali.

III

An emulsion breaks whenever the hydrophilic (lyophilic) colloid which holds the aqueous dispersion means is either diluted beyond the point at which it can take up all the offered water, or is so influenced by external conditions that its original capacity for holding water is sufficiently reduced.

Certain emulsions, as those of oil in soap, therefore, tend to break on simple dilution. But agents which dehydrate the hydrophilic colloid act even more rapidly and effectively. What will prove to be effective agents in this regard depends, of course, upon the character of the hydrophilic colloid stabilizing the emulsion. When alkali-casein is used, the addition of acid breaks the emulsion, while alkali will break an emulsion stabilized by acid-casein. The same concentration of acid or alkali is without effect upon an emulsion stabilized by a carbohydrate like acacia, or dextrin. Since even neutral salts will dehydrate an acid- or alkali-protein, they readily serve to break emulsions stabilized by these substances. An emulsion of oil stabilized in soap is readily broken not only by acids and various salts, but also by alcohol. Ether, on the other hand, is relatively ineffective. Practically all these substances in low concentrations are without effect upon emulsions stabilized in hydrated carbohydrates.

The fact that alcohol and ether are by themselves thus relatively ineffective in breaking emulsions explains why the ordinary fat extraction methods are so often only partially effective in getting the fat out of biological materials, and why previous treatment of the material, as by digestion with strong acids or alkalies and by similar methods, yields higher fat figures than extraction with ether or allied materials alone.

IV

The problem of the distribution of fat in living cells or in various secretions from the living tissues may be separated into two divisions; first, a chemical one dealing with such questions as that of the origin and transport of fat, and second, a physical one asking, for

example, how smaller or larger amounts of fat may be stored in cells without at one time being visible or demonstrable by micro-chemical methods, while at another, as in "fatty degeneration," they are.

There is scarcely a tissue or fluid of the body which even in the poorest states of nutrition, does not contain some fat. But even the smallest amounts of fat thus found exceed the quantities that can be dispersed in permanent form in pure water. The presence of such amounts of fat in these structures, therefore, at once presents a problem identical with that which asks how it is possible, outside of the body, to maintain a fat in finely divided form in an aqueous dispersion means. *The presence of any amount of fat in a cell or tissue exceeding a fraction of one per cent. is possible only because the tissues contain hydrophilic colloids.*

Looked at from another point of view, even the smallest amounts of fat ever found in cells suffice to prove that *the cell contents are not mere aqueous solutions of various salts and non-electrolytes contained in a semi-permeable bag,* as is so generally believed by the adherents of the osmotic conception of cell constitution.

How completely the notion that our cells are filled with salt solutions must go to pieces, becomes clearly evident when it is recalled that certain of our cells and tissues contain even normally some twenty-five per cent. of fat and fat-like bodies. Thus, of a hundred grams of nerve tissue, seventy grams are water, and over twenty grams are fat. The remainder is protein chiefly. *Nerve tissue and all tissues which, under normal or abnormal circumstances, hold such large quantities of fat are able to do so only because this material is stabilized in a finely divided state through the presence of hydrophilic colloids (like proteins and soap) which hold the water of the cells as a hydration compound.*

While the fat in the cells of the body is not ordinarily visible in the state in which it exists here normally, certain pathological conditions popularly termed "fatty infiltration" or "fatty degeneration" suffice to make the fat readily visible. The older pathologists believed that more fat was thus visible for the reason that the cells had come to contain more (either because this had been brought to, or stored in the cells) or because their protein had been changed to fat. Modern studies of the question have proved the last of these possibilities to be entirely without foundation, so that now both "fatty infiltration" and "fatty degeneration" are at the worst held to be nothing more than states in which an excessive deposition may occur. But quantitative chemical studies have come to show that even the worst types of fatty degeneration in tissues may yield no fat figures lying beyond the amounts commonly found in these same localities under physiological conditions. In the majority of instances chemical analysis fails to show that the affected cells contain any more than their normal fat content. *In essence, therefore, "fatty degeneration" no longer represents a chemical, but a physical problem, which asks how a given quantity of fat usually so distributed in a cell as to be invisible, becomes re-distributed in such fashion as to be readily visible.*

We believe this problem is identical with that which asks how an emulsion of oil in protein or soap (so fine that the individual oil droplets can not be made out as more than granules even with high microscopic magnification) can be broken to the point where the fat granules will coalesce to form more readily visible droplets. As a matter of fact, detailed study of the conditions which are necessary for the production of typical "fatty degeneration" in tissues shows these to be identical with those which lead to the breaking of emulsions of the type of oil in alkali-casein, oil in soap, etc.

The various substances generally listed as capable of producing a "fatty degeneration" (phosphorus, lead, arsenic, mercury, alcohol, ether, chloroform, diabetes, local circulatory disturbances, intoxication with acids, etc.) are all of them means by which the normal hydration capacity of the soaps or of certain of the proteins of the cell (as the globulins) is markedly decreased. The matter is best illus-

trated, perhaps, by detailing a specific instance.

When a cell, in consequence of injury, is made the subject of an acid intoxication by any of the direct or indirect means enumerated in the last paragraph, the acid makes some of the proteins of the affected cells swell, while another group (the globulins) is dehydrated and precipitated. The combination of swelling with precipitation yields what the pathologists call "cloudy swelling." But as the pathologists have long noted, a persistence of cloudy swelling is followed, almost as a rule, by a "fatty degeneration" of the affected cells. On the basis of our remarks this coalescence of the oil droplets into the larger visible ones of "fatty degeneration" is dependent upon the removal, through the action of the acid, of some of the stabilizing effects of the proteins, soaps and other hydrophilic colloids contained in the cells. The increased swelling represents a dilution of the hydrophilic colloids of the cell, while the clouding represents a dehydration of certain others.

These studies on emulsions contribute toward the explanation of yet another pathological observation. When any tissue, as a portion of the brain, through some such pathological disturbance as a thrombosis is deprived of its normal blood supply, the affected member shows first a cloudy swelling accompanied or succeeded by a "fatty degeneration," and then a "softening" of the tissues. How at least a portion of this (and we are inclined to think the major portion in such tissues as the brain) is brought about is illustrated in the changes in viscosity observable in the preparation of an emulsion or its subsequent destruction. Seven per cent. potassium soap and cottonseed oil, for instance, are both relatively mobile liquids, but when mixed in proper proportion they yield an emulsion so stiff that it will stand alone. This is the analogue of the twenty-five per cent. emulsion of fat and lipoid in hydrated protein which we call the brain. If the oil-in-soap emulsion is broken through the addition of a little acid it yields an impure mixture of oil, water and precipitated colloid material—the analogue of the liquid contents found in any area of brain "softening."

Application may also be made of these studies to the problem of the giving off of such essentially fatty secretions as make up ear wax, vernix caseosa, sebum, the fatty secretions of plants, etc. *These all represent a transition from the normal type of oil in hydrophilic colloid emulsion to that of hydrophilic colloid in oil emulsion.* A homely analogue of this type of change is seen in butter-making, which consists of changing cream (essentially an emulsion of oil in hydrophilic colloid) into butter (a fat into which are divided about fourteen per cent. of water). Similarly, the essentially fatty secretions from the body as well as the fat contained in the adipose tissues of the body, all prove to be fats containing some seven to fifteen per cent. of water emulsified in them.

The details of these observations will be published in the *Kolloid-Zeitschrift.*

Martin H. Fischer,
Marian O. Hooker
Eichberg Laboratory of Physiology,
University of Cincinnati

GRAVITATION AND ELECTRICAL ACTION[1]

In former publications the present writer has suggested that there is an intimate relation between gravitation and electrical action at a distance, or what has been called statical effects. There can be no doubt of the truth of the statement that the attraction between two masses of matter depends not only upon the amount of matter in the two masses, and their distance from each other, but also upon their electrical potential.

The gravitation constant has been determined by finding the attraction between two spheres of metal. In these determinations the electrical potential of the masses has been ignored. It has been assumed that there are no electrical charges on the two masses, if their potential is that of the earth.

Assume that two spheres, having radii R_1 and R_2 composed of metal having a density ρ,

[1] Extract from a forthcoming number of the *Transactions of the Academy of Science of St. Louis.*

and distant from each other r, have charges Q_1 and Q_2, the spheres having a common potential V. Their attraction for each other will be

$$A = K\frac{m_1m_2}{r^2} - \frac{Q_1Q_2}{r^2}$$

$$= K\frac{16}{9}\frac{\pi^2R_1^3R_2^3\rho^2}{r^2} - \frac{R_1R_2}{r^2}V^2$$

Here K is the value of Newton's constant of gravitation, as it would be determined by the method of Cavendish or Boys, if V were zero absolute.

If V is not zero, and the second term is omitted, the last equation might be written

$$A = K\left(1 - \frac{x}{100}\right)\frac{16}{9}\frac{\pi^2R_1^3R_2^3\rho^2}{r^2}$$

In this equation $K[1-(x/)100)]$ is the gravitation constant that would be determined under such conditions. Both K and x would remain unknown quantities.

Equating these two values of A

$$V = \tfrac{4}{3}\pi R_1R_2\rho\frac{\sqrt{Kx}}{10}$$

If V is measured in volts

$$V = 40\pi R_1R_2\rho\sqrt{Kx}$$

If $R_1=10$, $R_2=1$, $\rho=11.35$ and $K=6.6576\times10^{-8}$

$$V = 3.68\sqrt{x}$$

This result shows that if these two spheres have a common potential which differs from absolute zero by 3.68 volts, the value of K as determined by the Cavendish method will be in error by one per cent. of the above value which is that of Boys. If V were ± 8.23 volts, an error of five per cent. would result. If V were 36.8 volts the two spheres would cease to attract each other. The absolute zero in V would be the common potential of the two bodies, when their attraction for each other is a maximum.

Storm clouds and the electrified atmosphere are continually acting inductively upon the earth's surface. The potential difference at the ends of a flash of lightning may amount to thousands of millions of volts. Aside from such disturbances, we are wholly in the dark concerning the average potential of the earth.

It is evident that the smaller the masses used in such determinations, the greater will be the possibility of error in the result, when the potential term is ignored.

It seems very probable that we do not know the real value of the gravitation constant.

FRANCIS E. NIPHER

SOCIETIES AND ACADEMIES

THE AMERICAN MATHEMATICAL SOCIETY

THE one hundred and eighty-second regular meeting of the society was held at Columbia University on Saturday, February 26, extending through the usual morning and afternoon sessions. The attendance included forty-three members.

The president of the society, Professor E. W. Brown, of Yale University, occupied the chair, being relieved by Professors H. B. Fine, T. S. Fiske and H. S. White. The following persons were elected to membership: Mr. L. E. Armstrong, Stevens Institute of Technology; Professor Grace M. Bareis, Ohio State University; Professor G. A. Chaney, Iowa State College; Mr. J. E. Davis, Pennsylvania State College; G. H. Hardy, M.A., Trinity College, Cambridge, England; Mr. Harry Langman, Metropolitan Life Insurance Company, New York City; Mr. E. D. Meacham, University of Oklahoma; Dr. A. L. Nelson, University of Michigan; Mr. Elmer Schuyler, Bay Ridge High School, Brooklyn, N. Y. Six applications for membership were received.

The society has recently taken over the stock of the Chicago Papers and Boston Colloquium Lectures, heretofore in the hands of The Macmillan Company. All publications of the society, so far as in stock, are now obtainable directly from the main office. The New Haven Colloquium was published by the Yale University Press, and is sold by them.

The List of Members of the society for 1916 has just been issued. Copies may be obtained from the secretary.

The following papers were read at this meeting:

T. H. Gronwall: "A functional equation in the kinetic theory of gases (second paper)."

T. H. Gronwall: "On the zeros of the functions $P(z)$ and $Q(z)$ associated with the gamma function."

T. H. Gronwall: "On the distortion in conformal representation."

C. A. Fischer: "Equations involving the derivatives of a function of a surface."

E. W. Brown: "Note on the problem of three bodies."

H. Bateman: "A certain system of linear partial differential equations."

H. Bateman: "On multiple electromagnetic fields."

A. R. Schweitzer: "On a new representation of a finite group."

A. R. Schweitzer: "Definition of new categories of functional equations."

E. B. Wilson: "Critical speeds for flat disks in a normal wind theory."

E. B. Wilson: "A mathematical table that contains chiefly zeros."

E. B. Wilson: "Changing surface to volume integrals."

T. H. Gronwall: "Elastic stresses in an infinite solid with a spherical cavity."

T. H. Gronwall: "On the influence of keyways on a stress distribution in cylindrical shafts."

O. E. Glenn: "The formal modular invariant theory of binary quantics."

O. E. Glenn: "The concomitant system of a conic and a bilinear connex."

P. R. Rider: "Trigonometric functions for extremal triangles."

H. S. Vandiver: "Symmetric functions of systems of elements in a finite algebra and their connection with Fermat's quotient and Bernoulli's numbers (second paper)."

S. A. Joffe: "Calculation of eulerian numbers from central differences of zero."

The next meeting of the society will be held at Columbia University on April 29. The Chicago Section will meet at the University of Chicago on April 21–22. The summer meeting of the society will be held this year at Harvard University early in September. At the eighth colloquium of the society, held in connection with the summer meeting, courses of lectures will be given by Professors G. C. Evans, of Rice Institute, on "Topics from the theory and applications of functionals, including integral equations," and by Professor Oswald Veblen, of Princeton University, on "Analysis situs."

F. N. Cole,
Secretary

THE BIOLOGICAL SOCIETY OF WASHINGTON

The 551st regular meeting of the society was held in the Assembly Hall of the Cosmos Club, Saturday, February 26, 1916, called to order at 8 P.M. by President Hay. Fifty persons were present.

The first paper on the program was by D. E. Lantz, "An Early Seventeenth Century Mammalogist." This was a review of Edward Topsell's "History of Foure-footed Beastes," published in London in 1607. Topsell was born about 1538 and at the completion of this, the first general work on mammals published in the English language, was chaplain of the church of St. Botolph, Aldergate, under Richard Neile, Dean of Westminster, to whom the book is dedicated. The work, including illustrations, is largely translated from Conrad Gesner's "Historia Animalium," published in 1551; but the author quotes also from over 250 other writers, Hebrew, Greek, Latin, German, Italian and French authorities, and including 76 medical treatises. The speaker gave many curious extracts from Topsell illustrating them with lantern pictures of the animals under discussion, taken from the old wood cuts in the book. The pictures included the antelope, an ape monster, the American sloth, the beaver, various kinds of hyenas, the unicorn, the riverhorse and the Su, an untamable and ferocious animal that has been identified with the American opossum.

The second and last paper on the program was by J. W. Gidley, "A Talk on the Extinct Animal Life of North America." Mr. Gidley defined the terms fossil, petrifaction, explained how fossils were formed under various conditions and how they are discovered by the collector. He discussed the evolution of certain animals as shown by their fossil remains as particularly exemplified by horses, elephants and dinosaurs. He emphasized in especial the unfortunate tendency on the part of paleontologists to try to see in fossil remains ancestral forms of later fossils or of existing animals. The speaker thought that many fossils represented highly specialized types of their kind, some extinct animals being more highly specialized than their present-day representatives, in fact in many cases their extreme specialization has led to their extinction. In a general way fossil forms represent the evolution of certain groups but the immediate connecting forms are for the most part lacking. Mr. Gidley's communication was profusely illustrated with lantern views of fossil-bearing localities, of fossils, and of certain artists' restorations of fossils. Mr. Gidley's communication was discussed by Dr. L. O. Howard.

M. W. Lyon, Jr.,
Recording Secretary